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A REVIEW OF SOME EXPERIMENTAL WORK IN PIG FEEDING.

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FEATURES OF EXPERIMENTAL WORK.

In the following pages will be found brief abstracts of some of the more important experimental work in pork production during recent years. The subject was presented in more complete form in Bulletin No. 47 of the Bureau of Animal Industry.

In studying the results of experimental work it is important to bear in mind that different conditions influence strongly the work of different stations. At the conference of animal husbandry workers in Chicago during the International Live Stock Exposition of 1902, Prof. W. A. Henry called attention to this fact. He pointed out that an "average," to be of any scientific value, should summarize work conducted with all conditions—such as age of animals, breeding, kinds of feed, care, management, and season of the year—as uniform as possible, and should represent the results of the labor of one man conducted at the same station and extending over a very considerable term of years. These factors are all of the highest importance and it is essential that they be considered in studying results. Good feeders know that animals of different ages feed differently, that breed is often an influential factor, that all feeds do not have the same value in the ration, and that good shelter and regular and skillful feeding are highly essential to secure profitable results. It is also readily apparent that, if all other conditions are equal, an experiment conducted in Maine to compare the value of corn meal with that of whole shelled corn can not be averaged, but only compared, with one of a similar nature conducted in Iowa or Oregon; the factor of climate is important and influential. The results of an experiment with hogs fed in the summer months are not to be averaged with those obtained with similar animals under exactly similar conditions of feed, care, and management during the winter. Even where all conditions are similar and every care has been taken to make them as uniform as possible, seasonal variations of climate may inject another factor of error. The results of two experiments conducted by a corn-belt station, the one during 1901, the other in 1902, could not be averaged with pro-

priety, although they were conducted as uniformly as possible, because the year of 1901 in the Central West was one of drought and the summer exceptionally long and hot; whereas weather conditions were exactly the reverse during 1902, when an unusual amount of rainfall was recorded, with very low temperatures during the summer.

If the farmer will bear in mind the influence of these modifying conditions, he can better realize the difficulties that surround experimental feeding; he will better understand their value, and will find himself listening more carefully to the advice of experiment station workers, reading bulletins with more confidence, and condemning less hastily what seems to be inaccurate. If each farmer regarded himself, in a way, as an experimentalist and should spend a small amount of time in keeping records of his operations, studying the results with the aid of the information at his command, and if he should at the same time keep in touch with the authorities of his experiment station, there is little doubt that many of the problems now perplexing farmers would be brought much nearer to a solution and the business of feeding live stock rendered more systematic and profitable.

PRINCIPLES OF FEEDING.

PHYSICAL CHARACTER OF FEEDS.

Feeds, as regards their physical characteristics, are generally divided into two classes; namely, concentrated feeds, or concentrates, and bulky feeds, commonly called coarse fodder, roughage, or forage. The seeds of plants, whole or ground, and all such feeds as are produced from the by-products of commercial establishments (mills, packing houses, etc.) supply a large amount of nutriment in small bulk, and hence are called concentrates. The body of plants, in the form of hay of all kinds, straw, green fodder, pasture grasses, and roots and tubers, gives us bulky feed or roughage. Vegetables, such as pumpkins, and the waste fruit of orchards are often fed to animals and are in the category of bulky feeds. All of these supply a relatively small amount of nutriment and a large amount of feed material. Milk is, properly speaking, a bulky feed when fed to rather mature animals, particularly when skimmed. For young animals whole milk is the most "complete" feed known, but it is too expensive to feed any but the youngest animals or those that are to be brought to the highest condition in the shortest possible time.

RELATION OF BULKY FEED TO LENGTH OF ALIMENTARY CANAL.

The amount of bulky feed required is different with different species of animals and depends upon the complexity of the feed of the animal; and the kind and variety of feed, in turn, have a direct relation to the length and complexity of the alimentary canal. For example, in a

state of nature carnivorous animals, such as those of the cat and wolf tribe, have very short and simple alimentary canals and live upon flesh, which is a very simple diet. Herbivorous animals—that is, those that subsist exclusively upon grasses, browse, etc., such as the horse, ox, sheep, and goat—have the most complicated digestive apparatus and eat a very great variety of feeds. Between these two classes we have those animals that live both on a flesh and a vegetable diet, and with them the alimentary canal is longer and more complicated than that of the carnivora, but shorter and less complicated than that of the herbivora. The pig belongs to this class, which is denominated the omnivora. Domestication has changed the habits of animals considerably, and in so doing has changed the internal characteristics of the body. Domestic dogs and cats have been brought to subsist on a diet in which there is a rather large amount of vegetable matter. Pigs are fed almost exclusively on a vegetable diet and only occasionally indulge their appetite for an animal diet. As a consequence of this variation in the range of feed eaten in domestication these animals have a longer and more complicated digestive tract than the same species in the wild state.

FUNCTION OF BULK IN THE FEED.

The function of bulk in the feed is more than the mere furnishing of nutriment, for, in a mechanical way, it aids digestion. In the ruminant animals especially there is an enormous stomach content which must be comfortably filled if digestion is to be carried on properly. Hence, with this class of animals a great amount of hay, etc., is required, and they can also give the best returns from a bulky feed and subsist more satisfactorily than any others on hay or straw alone. Pigs require less bulky feed than other domestic animals, but recent experiments show that, to a certain extent, hay feeding is very valuable in pork production. Where herbivorous animals have been maintained for an extended period on feed which was exclusively of a concentrated nature derangement of digestion has resulted.

CHEMICAL COMPOSITION.

From a chemical standpoint the constituents of feeds that most immediately concern the feeder are the nitrogenous substances, generally termed protein compounds, which contain a large percentage of nitrogen; the starches, sugars, etc., called carbonaceous substances or carbohydrates, from the fact that they are composed of carbon, with hydrogen and oxygen in the proportions in which they occur in water (they are termed "nitrogen-free extract" in chemical analysis), and fat, found in analysis under the heading of "ether extract." Ash is also of importance and often should be more carefully considered when feeders are making up their rations.

WATER CONTENT.

The most valuable portion of feeds is the water-free substance or dry matter of the feed. This is what remains of a feed after heating it in a drying chamber at or near the boiling point until repeated weighings show no change in weight. The amount of water present in feed is obviously an important factor. While it yields neither tissue-building material nor energy, it enters into the composition of the body and is indispensable. When animals are compelled to take into the system water beyond the normal amount undesirable results will follow. When animals are fed exclusively on roots or skim milk they do not receive more than enough to maintain bodily functions. This is readily understood when we consider that roots contain about 90 per cent and skim milk about 88 per cent of water. On the other hand, hay does not ordinarily contain more than 15 to 20 per cent of water, while grains, leguminous seeds, and milling products contain only about 10 per cent. The water content of feed is very much influenced by weather conditions, especially in the case of roughage, which absorbs large amounts of moisture in wet weather.

ENERGY.

A factor that is being more carefully considered in studying the value of a feed or a ration is the amount of energy which it will yield. When feed is utilized in the animal body a certain amount of heat is evolved, the process not being unlike the consumption of fuel in a furnace. This heat is converted into the energy which is necessary whenever work is performed. It is apparent, then, that a horse at hard work will need a ration that will supply more energy than one at moderate or light work. The term "work," however, has a wider significance than denoting actual muscular effort in the performance of a task. The operations of mastication, deglutition, and the contraction of the walls of the stomach and intestines involve muscular action, both voluntary and involuntary; in the movements of the heart and lungs, and the circulation of the fluids of the body, muscular action of some kind is constantly going on; in fact, the performance of nearly every function of the body is actually some form of work involving the expenditure of energy, accompanied by the evolution of heat and maintained by the energy-yielding material in the feed. The amount of work performed by an animal in the ordinary processes of "hustling for a living"—that is, finding its feed, eating it, and digesting it—is enormous. In experiments, reviewed in the following pages, with suckling pigs, Miss Wilson found that the young animals required nearly as much energy per square meter of surface as had been found by other investigators to be required by a man at hard work. It is therefore readily apparent that the heat-producing powers of feed have a very much more important function than the

maintenance of bodily warmth. The unit of energy used in computing the value of a feed from this standpoint is the "small" calorie, which is the amount of heat necessary to raise 1 gram of water 1° C.

Fats yield a greater amount of energy than either the carbohydrates or protein, there being very little less energy given up by proteids when digested than by carbohydrates.

RELATION OF FEED TO THE ANIMAL BODY.

We have seen that the most important constituents of feed are the proteids, the carbohydrates, and the fats. These are practically all that the feeder considers in making up his rations, although the physiologist must consider other compounds which exist in smaller quantities. In the body we find, in the water-free matter, the proteids, the fat, and the ash.

The following table shows graphically the relation between the constituents of the feed and those of the body—that is, the disposition of the feed:

Disposition of feed in the body.

Feed.	Body.
Water	Water.
Proteids	Proteids.
Carbohydrates	Fat.
Fat	
Proteids (rarely)	
Ash	Ash.
Fat	Energy.
Carbohydrates	
Proteids	

It is seen that the water of the feed reappears as the water in the body. The proteids in the feed form the proteids in the body. The fat of the body is formed from the carbohydrates and fat of the feed and occasionally from the proteids. The ash of the body, such as the mineral matter of the bones, comes from the ash of the feed. The three principal feed constituents—fat, carbohydrates, and protein—yield energy in the order named, fat yielding the most energy for an equal weight of feed. The carbohydrates and proteids are practically equal in heat-yielding power.

Now, as different animals have different demands made upon them, we must expect them to require these constituents of feed in different proportions. To be more explicit, a young and growing animal is building up tissue rapidly, and this should be largely muscular and bony if the best health is maintained. Muscular tissue is largely made up of proteids, and we therefore expect a large amount of protein matter in the feed. There should also be a plentiful supply of mineral matter and phosphates so that the skeleton may be properly built up. As milk is rich in nitrogenous material, we find it an excellent feed for

growing animals. Again, animals that are to be fattened rapidly must have a large amount of fat-producing material in the ration, for which reason farmers find corn such a valuable feed for this purpose. Horses that are at hard work require a ration that will give an ample supply of energy. The large amount of energy yielded by fattening rations and heavy-working rations has an interesting bearing on the shelter requirements. Steers that are on full feed can enjoy themselves in the coldest weather if provided with a simple shed that will protect them from cold winds, rain, and snow, and human beings readily recognize the fact that where a large amount of exercise is indulged in with ample food a much greater amount of cold may be endured than where no exercise is taken and the ration is light.

DIGESTIBILITY OF FEED.

The amount of nutritive material which an animal can get from his feed is a very important factor. It is obvious that when skim milk or roots are fed alone immense quantities must be eaten to give a sufficient amount of nutritive material. A similar condition is met with when feeds having a low digestibility are given. For instance, when animals are wintered at straw stacks they acquire large stomachs by reason of gorging themselves with coarse, bulky feed, and generally have a half-starved appearance because they are not able to obtain from such feed an adequate amount of nourishment to maintain flesh and condition. Hay and straw contain large amounts of crude fiber, which is composed of carbohydrate material, largely cellulose, and which is only partially digestible. The crude fiber in grains is insignificant, except in the hulls, and hence their higher digestibility.

THE NUTRITIVE RATIO.

In discussing feeding the term "nutritive ratio" is frequently met. This means simply the ratio between the total amount of digestible protein in a ration (that is, one day's feed) to the total amount of digestible carbohydrates plus 2.25 times the digestible fat. The fat is of greater value for the purpose of yielding energy than the carbohydrates, and chemists have determined that this ratio is about 2.25; hence the reason for this factor in the computation of a ration. As the functions of the fat and the carbohydrates are very similar, the reason is apparent for the addition of the former. There are many publications available that discuss in detail the computation of rations. One of the principal things to avoid is getting a ration which, while correct so far as nutritive ratio is concerned, can not be fed successfully on account of its low digestibility or high water content.

PREPARATION OF FEED AND METHODS OF FEEDING.

Investigation of the different methods of preparing feed was one of the earliest efforts of the experiment stations made in animal hus-

bandry. Perhaps the first phase of the subject to be studied was the utility of cooking feed; indeed, long before the establishment of experiment stations in the different States individual investigations and agricultural colleges had pretty thoroughly covered this subject. Their results may be summed up by stating that for fattening pigs cooking is an expensive practice, the results not being in proportion to the added cost. However, for breeding stock and sick animals, and for animals which it is desired to put into the very highest condition, cooking may be practiced with good results if expense is disregarded. Pigs so fed show marked thriftiness and health.

The utility of grinding grain is, however, still under investigation. Whereas the almost universal opinion is that, with the exceptions mentioned, cooking feed is not to be advised, the results of experiments to compare ground and unground grain are not yet regarded as showing beyond question that grinding is or is not a wise and economical practice.

The theory of grinding grain is that when the feed is in the condition of a meal it is more readily or quickly available for digestion. It is fallacious to claim that a feed given as meal contains more digestible matter than the same feed before it has been reduced to the condition of meal, for that is a thing that is obviously impossible; but it is not, perhaps, incorrect to say that the digestive fluids may be more effective in their action on feed that has been crushed or ground, and that less undigested matter is voided by the animal than when whole grain is given. The amount of the feed that is absorbed (digested) in its passage through the body, plus the undigested nutrient content of the excrement, practically equals the total digestible matter in the feed before eaten. All practical feeders readily recognize the great possibility of loss by way of the excrement when feeding steers on shelled or ear corn, and to obviate this they use hogs to consume the waste. Some waste is inevitable. There can not be perfect feeds or perfect digestions, but we may avoid wasteful methods, and the feeder's problem is to render the loss of feed in the manure as small as possible. It is unnecessary to remark that grain which is swallowed without being masticated is much more likely to pass undigested than when thoroughly masticated before swallowing. The kind of grain that is more readily masticated when fed whole would therefore seem to be less in need of grinding than that which is more generally swallowed without thorough mastication.

Results at the Central Experimental Farm[a] of Canada showed that the smaller grains, such as oats and barley, generally passed through the alimentary canal of pigs with the least amount digested. The average of nineteen experiments with 297 pigs at six experiment sta-

[a] Bul. No. 33.

tions where corn meal and whole shelled corn were compared show[a] the feed per 100 pounds of gain to be 524 pounds where whole corn was fed and 479 pounds where corn meal was fed—a difference of nearly 8.59 per cent in favor of grinding. Henry's[b] researches at the Wisconsin Experiment Station have been the most exhaustive which have been undertaken on this subject.

In twelve tests, covering seven years of work, with a total of 210 pigs, he found a saving of feed from grinding in nine instances, the highest being 17.6 per cent and the lowest 3 per cent. In the three cases where there was a loss it was, respectively, 9 per cent, 2 per cent, and 1 per cent.

Grisdale found in comparing ground and whole pease that the pigs on both feeds made practically the same gains, but those on the ground feed ate only 276 pounds per 100 pounds of gain, as compared with 333 pounds of feed per 100 pounds of gain with the pigs on whole pease—a saving of 17 per cent by grinding the grain.[c]

The amount of material available on the subject of grinding small grain is not so voluminous as that pertaining to corn. In the United States a great amount of the oats, wheat, barley, or rye fed is in the form of mill products and is, of course, ground. These feeds are, moreover, generally used as supplements to corn, and the greater attention has been directed to methods of corn feeding on this account. In common practice, perhaps, these grains are ground more generally than corn, as they are usually much harder. Their greater liability to pass through the animal undigested shows the correctness of such practice.

At the Colorado Station[d] four tests with ground and unground bald barley and three with ground and whole common barley showed larger gains and a marked saving of feed with the ground grain.

The average of ten tests with 69 pigs at five other stations shows gains[e] at a cost of 473 pounds of feed where small grains were fed whole and 415 pounds when they were fed as meal—a saving of 12.26 per cent by grinding. Soaking feed for pigs has been the general custom among farmers, but within recent years some feeders have adopted the practice of giving all grain dry, especially during winter in cold climates where wet feed is easily chilled or frozen. Considerable attention has been given this subject by experiment stations.

The writer has averaged the results at eight stations, comprising twelve tests in all, with 89 pigs. Dry feed showed gains at a cost of 444 pounds of grain for 100 pounds of gain, and wet or soaked grain

[a] Bul. No. 47, pp. 79–81, Bureau of Animal Industry.
[b] Nineteenth An. Rpt.
[c] Bull. No. 33, Central Expt. Farm.
[d] Bul. No. 40.
[e] Bul. No. 47, pp. 83–85, Bureau of Animal Industry.

gave gains at a cost of 434 pounds of grain for 100 pounds of gain—a saving of slightly over 2 per cent in favor of feeding grain wet or soaked. At the Indiana Station, Plumb and Van Norman[a] fed pigs on dry meal, on meal plus its weight of water, meal plus twice its weight of water, and meal plus three times its weight of water. Dry feeding showed no larger gains, but they were much more economical than on wet feed. The addition of large quantities of water seemed to have no effect on either the rate or economy of gain.

The comparative feeding values of wide and narrow rations continue to be studied, and results over a series of years at the Iowa[b] and Wisconsin[c] stations have shown that for pigs a wide or carbonaceous ration gives larger and more economical gains than a narrow one. An exception is noted on two tests in Wisconsin, where a ration of pease alone gave better results than one of corn alone. These tests show, pound for pound, a greater value for pease than for corn, but it is suggested that, considering market prices of feed, corn is the cheaper. The better appetite of the pea-fed pigs was remarked upon in both tests, but especially in the last one. Some investigators have not found pease to be successful when fed alone. Day[d] states that at Guelph pea feeding resulted in poor gains and unthrifty animals, but feeding a mixture of 3 parts pea meal and 1 part middlings gave good gains and produced excellent bacon.

The effect of a narrow ration on the external appearance of the pigs was noted in the Wisconsin experiments. Toward the end of the experiment, when pea meal and shorts were compared with corn meal and rye meal, the luxuriant hair and smoother flesh of the pea-fed pigs were remarked upon. The corn-fed pigs were less smooth, had deeper wrinkles, and the flesh showed a tendency to be soft and roll over the shoulders and flanks.

CORN AND CORN SUBSTITUTES.

To the farmer of the corn belt those experiments with grains which may take the place of corn for feeding purposes in times of scarcity are always interesting. In seasons such as that of 1901, when a summer of extreme heat and little or no rain follows a spring of normal conditions, the short corn crop is frequently counterbalanced by a bountiful supply of small grains. Many farmers at such times rely on wheat, barley, oats, and rye to carry their stock to marketable condition. Outside the corn-growing districts such experiments are of even more importance, for the small grains are often grown in great abundance and form the basis of all rations.

In a comparison of whole wheat, both soaked and dry, with a ration of whole corn and one of equal parts of corn and wheat the Indiana

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[a] Bul. No. 86.
[b] Bul. No. 48.
[c] Eighteenth and Nineteenth An. Rpts.
[d] An. Rpt. 1899, Ontario Agr. Coll.

Station[a] obtained better results both in rate and economy of gain with the corn rations, but the gains from the wheat rations were satisfactory.

The Utah Station[b] compared rations of ground wheat and corn meal, the ground wheat giving larger and more economical gains.

Where a ration of ground wheat was compared with one of equal parts of corn meal and pea meal, the gains were larger but slightly more expensive with the corn-fed pigs. In a rather comprehensive experiment the Nebraska Station[c] compared various rations in which corn, wheat, or rye were fed alone or in combination with each other or with shorts. Dry ground wheat gave the greatest returns and the least amount of grain required for 100 pounds of gain, but did not return so large a profit as soaked whole wheat, owing to the expense of grinding. A ration of ground wheat and corn gave considerably better results than one of ground wheat and rye or ground wheat and shorts. Ground corn and ground rye alone did not appear to advantage. Nine experiments at the Central Experimental Farm of Canada,[d] where wheat which had been more or less damaged by frost was fed alone, ground, unground, and in combination with other grains and skim milk, show that the injury by frost did not seem to have a serious effect on the feeding value of the wheat. In the majority of instances the gains made were satisfactory, and those cases in which a large amount of grain was required for 100 pounds of gain were generally with hogs of considerabl· maturity, and consequently expensive feeders. Considerable study has been made of the value of barley as pig feed, and the results have been that it compares very favorably with corn, having a feeding value somewhat below that of wheat. What this grain may lack in feeding value, however, it more than supplies in its effect on the carcass. As a high-grade pig feed it far surpasses any other grain, and this fact makes possible the production of pork of the first quality in localities where corn is not a staple crop, but where barley is produced abundantly. An experiment in Canada with oats and corn showed rather small and expensive gains from oats.

The Oklahoma Station[e] compared Indian corn and Kafir corn as follows:

Six pigs, averaging about 135 pounds at the beginning of the test, were fed six weeks on Kafir heads, and made an average daily gain of 1.11 pounds, requiring about 665 pounds of grain for 100 pounds of gain.

Three pigs, averaging 220 pounds at the beginning, made an average daily gain of 1.53 pounds for thirty-five days, and required the equivalent of 494 pounds of shelled corn for 100 pounds of gain. These

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[a] Bul. No. 67.
[b] Bul. No. 70.
[c] Bul. No. 75.
[d] Bul. No. 33.
[e] An. Rpt., 1898–99.

same pigs were then fed Kafir meal for two weeks and made 1 pound of gain per head daily, eating 921 pounds of meal for each 100 pounds of gain.

Four pigs, averaging 105 pounds, were fed for thirty-five days on Kafir meal. They made an average daily gain of 1.21 pounds, eating 508 pounds of meal for 100 pounds of gain. For the next two weeks they were given soaked shelled corn. They made a total gain of only 30 pounds, eating 707 pounds of corn for 100 pounds of gain. For the next four weeks a daily supply of green alfalfa was given with good effect. A total gain of 140 pounds was made, requiring 365 pounds of grain for 100 pounds of gain.

The value of Kafir corn for hogs has been studied extensively at the Kansas Station. Kafir corn was found to have a feeding value considerably below that of corn when both grains were fed alone. Cottrell[a] states that the average of a number of trials shows that 527 pounds of Kafir corn and 468 pounds of Indian corn, respectively, are required per 100 pounds of pork made; the yield of pork per bushel of grain being 10.6 pounds in case of Kafir corn and 11.9 pounds with Indian corn. On upland soil, however, the average of eleven years on the Kansas Agricultural College farm shows returns of 46 bushels per acre for Kafir corn and 34½ bushels for Indian corn. Such returns, with gains as noted above, indicate a pork yield per acre of grain at 487 pounds for Kafir corn and 410 pounds for Indian corn. The great value of Kafir corn is its ability to resist drouth.

In addition to the lighter returns from Kafir corn than from Indian corn, this grain is very constipating when fed alone, and hogs, especially young ones, tire of it sooner than they do of Indian corn. To remedy these difficulties a mixture is advised, especially with feeds of a laxative nature. One of the most convenient nitrogenous concentrates at the hands of the Kansas farmer is the soy bean.

In a series of five experiments[a] the effect of such an addition to both Indian corn and Kafir corn rations was studied. In every case increased gain was obtained by the use of soy beans, the lowest being 14.6 per cent and the highest 96.4 per cent, where a ration of Kafir corn meal four-fifths, soy-bean meal one-fifth was compared with one of Kafir corn meal alone. The amount of feed saved by the use of soy-bean meal varied from 13.2 per cent to 37.5 per cent. The amount of soy-bean meal fed was generally one-fifth of the ration and never more than one-third. In a tabulation[a] of the feed required per 100 pounds gain of 25 lots fed various rations the average was 528 pounds feed per 100 pounds gain. The lowest requirement was 369 pounds of feed per 100 pounds gain made by a lot on a ration of corn meal two-thirds, soy-bean meal one-third. The soy-bean meal rations were

[a] Bul. No. 95, Kansas Expt. Sta.

far superior to rations of Indian corn or Kafir corn alone in any condition.

The six lots of hogs having soy beans as part of their ration required an average of 411 pounds of grain for 100 pounds of gain, while the 19 lots not fed soy beans required an average of 564 pounds of feed per 100 pounds of gain, an increase in feed required of over 37 per cent. The effect of feeding soy beans is good. Hogs receiving them fatten rapidly, look thrifty, have strong appetites, and the hair and skin are glossy, like those of animals fed oil meal.

Experiments at the Utah Station[a] compared the values of pease and wheat during two years. The pigs were confined in yards and the grain given whole and dry. Pease give larger gains than wheat, and less feed was required per 100 pounds of gain.

At the South Carolina Station[b] Newman and Pickett fed to compare cowpeas with corn. The pigs were from eight to eleven months old and were fed in pens. There were 3 pigs in each lot.

The cowpea-fed lot ate 6.7 pounds of cowpeas per head daily and made an average daily gain for the lot of 3.38 pounds. They required 491 pounds of cowpeas to produce 100 pounds of gain.

The corn-fed lot ate 9.2 pounds of corn per head daily and made an average daily gain for the lot of 4.17 pounds. They required 602 pounds of corn to produce 100 pounds of gain.

With pork at 5 cents per pound and corn and cowpeas yielding 15 bushels and 10 bushels, respectively, per acre, the value of an acre of corn in this experiment was $6.97 and that of an acre of cowpeas $6.12.

At the Alabama Station[c] Duggar fed two lots of pigs to compare the relative value of a ration of half corn meal and half ground peas with that of an exclusive corn-meal ration. The pigs used were placed in covered pens, with small yards adjoining, and, after a preliminary period of a week, put into the experiment, which lasted sixty days. The results are as follows:

Ground cowpeas and corn meal compared with corn meal for pigs.

Ration.	Gain.	Number of days fed.	Feed eaten.	Feed per 100 pounds of gain.
	Pounds.		*Pounds.*	*Pounds.*
Ground corn alone	68	60	548.2	806
Corn ½, cowpeas ½	108	60	569.9	528

In this experiment the cowpea and corn-meal ration made gains 34 per cent more economical than corn alone. The quality of the pork made was as good as that of corn-fed pork.

In another experiment the Alabama Station[c] compared the feeding value of peanuts and corn meal, the peanuts being fed dry and unhulled.

[a] Bul. No. 70. [b] Bul. No. 52. [c] Bul. No. 93.

Rations of peanuts alone, corn meal alone, and equal parts of peanuts and corn meal were fed. The best results were obtained from the pigs on corn meal and peanuts, judging from the standpoint of rate of gain. In feed per 100 pounds of gain, the pigs on peanuts alone were the most economical feeders. The pigs on corn meal only fed and thrived poorly. Those on peanuts alone made a gain of 9 pounds per bushel of peanuts, which gives peanuts a value of 27 cents per bushel with pork at 3 cents per pound, and 31½ cents per bushel when pork is at 3½ cents per pound.

At the South Carolina Station, Newman and Pickett[a] fed two lots of grade Berkshire and Duroc Jersey pigs, from eight to eleven months old, in pens, to study the relative values of peanuts and corn. On land of similar character they estimated the corn yield at 15 bushels per acre and peanuts 90 bushels, and in their investigations they found that, with exclusive corn feeding, 602 pounds of corn were required for 100 pounds of gain and with peanuts 443 pounds for 100 pounds of gain. On this basis, an acre of corn will produce 139.5 pounds of pork and an acre of peanuts 487.5 pounds, worth, respectively, when pork is 5 cents per pound, $6.97 and $24.37.

COMMERCIAL BY-PRODUCTS.

One of the prominent features of modern industry is the development of the possibilities of the by-product—the waste and offal of manufacturing establishments. Farmers have long appreciated the value of the by-products of flour mills, but of recent years many other materials have come into the market as valuable feed for farm animals. Rice mills, oil mills, and packing houses all have their by-products, which are useful in supplementing the products of the farm.

MILLING PRODUCTS.

The by-products of the flour mills have for years been bought by farmers for use in the feed box, and one of these—middlings—has come to have an unsurpassed reputation for hog feeding, especially for young animals in the early stages of fattening. With the development of milling the ingenuity of the manufacturer has enabled him to throw a host of new foods upon the market. In consequence, we have, in the first place, a by-product more completely deprived of its nutrient material, perhaps, than formerly, but more uniform in quality; and, in the second place, a greater variety of feeds with which to supply the bins. It is not alone the products of the flour mills that have value for feeding purposes. The rice mills, glucose factories, and oil mills all have by-products that are useful adjuncts to feeding operations. Indeed, most of the experimental work of recent years

[a] Bul. No. 52.

deals with the value of the by-products of these industries. In the majority of instances these feeding stuffs are best used as adjuncts to corn or corn meal, although often the proximity of feed yards to a mill cheapens the by-products sufficiently to enable the feeder to use them as the main part of the ration.

The New Hampshire Station [a] fed two lots of pigs to compare the value of a corn meal and skim milk ration to which bran had been added with one of corn meal and milk only. The addition of bran was not advantageous, larger gains being made and less feed required by the pigs on corn meal and milk. The Colorado Station [b] compared shorts and corn meal in various rations. The pigs on shorts and other grain made larger and more rapid gains than those on corn meal and other grains, but more feed was eaten and more required per 100 pounds gain. The cost per 100 pounds gain, however, was the same. The Indiana Station [c] compared a ration of corn meal and shorts with one of corn meal only. The addition of shorts in this case increased the gains and lessened the amount of feed required per 100 pounds gain. The cost per 100 pounds gain was also less when shorts were added. The South Carolina and Alabama stations have shown that some of the by-products of rice milling have as great value in pig feeding as corn meal when they are not adulterated with chaff, bran, or other inferior substances. These products are sold under the names of rice meal, rice polish, rice flour, etc., and vary in composition according to the caprice of the miller—rice meal, for example, very often containing large quantities of rice bran, which is of little feeding value, and hence decreases the utility of the by-products with which it may be mixed. An experiment at the South Carolina Station [d] showed somewhat larger and more rapid gains from a ration of rice meal and skim milk than from a ration of corn meal and skim milk. The cost per 100 pounds gain from the rice ration was much cheaper.

The Alabama Station [e] reports seven tests with rice polish. It was compared with corn meal with and without the addition of skim milk, and in a mixed ration of cowpea meal and wheat bran; with a ration of one-half cowpea meal, one-fourth corn meal, and one-fourth rice bran, with the addition of skim milk; and in different proportions with other feeds without skim milk. The pigs used were generally recently weaned and the meal was fed dry.

The pigs on rice polish made more rapid gains than those on corn meal or mixed-grain rations, and in all but two cases the rice-polish ration was more economical. This station summarized the results where rice polish and corn meal were compared directly, and found that an average of 373 pounds of rice polish were required to produce

[a] Bul. No. 66. [b] Bul. No. 74. [c] Bul. No. 71. [d] Bul. No. 55. [e] Bul. No. 122.

100 pounds gain, as compared with 474 pounds of corn meal. "At this rate, 78.6 pounds of rice polish were equal to 100 pounds of corn meal, a saving of 21.4 per cent of the grain by the substitution of polish for corn meal."

In Massachusetts the Hatch Station[a] compared hominy meal and corn meal. The latter is described as consisting of "the hulls, germs, and some of the starch and gluten of the corn ground together. This separation is said to be brought about solely by the aid of machinery. The hard flint part of the corn is the hominy, which is used as a human food." Milk was given to all lots. The results seem to show that hominy meal has a feeding value equal to that of corn meal. In this one test corn meal failed to give quite so good results as the hominy meal, showing an average daily gain of 1.28 pounds to 1.39 pounds for hominy meal and 320 pounds dry matter for 100 pounds gain to 306 pounds dry matter for 100 pounds gain in the case of the hominy meal.

Two tests were made at the Hatch Station[a] to compare corn meal and cerealine feed. Like hominy meal, cerealine feed "consists also of the hull and a portion of the starch of the corn. It contains rather less of the starch than the hominy meal. It is the by-product resulting from the preparation of the breakfast food known as cerealine flakes. It is very coarse looking and appears very much like unground corn hulls." In these tests cerealine feed showed considerable value as a pig feed, but failed to give as good results, either in rate or economy of gain, as corn meal. Digestion experiments at the Hatch Station with sheep have shown that cerealine feed contains as much digestible matter as corn meal. The station authorities suggest that the coarse nature of cerealine feed lessens its value as a pig feed.

An experiment at the Maryland Station[b] to compare the value of gluten and linseed meals to balance a pig's ration gave results in favor of gluten meal. The rate of gain, feed per 100 pounds gain, and cost of gain all favored this by-product.

COTTON-SEED MEAL.

No feed of the South has so wide a range of interest as cotton-seed meal. It is depended upon by feeders of cattle and sheep in all parts of the country to balance their rations, and it has an effect on the fertilizing value of the manure which is nearly as great as its effect on the feeding value of the ration. In many parts of the South and in foreign countries cotton seed and cotton-seed meal are applied directly to the land as fertilizers.

For cattle and sheep feeding cotton seed and cotton-seed meal may be fed with reasonable safety. When fed to cattle for long periods

[a] Eleventh An. Rpt. [b] Bul. No. 63.

in large quantities it is said to sometimes cause blindness, and occasionally death. With hogs, however, feeding is usually fatal in from three to ten weeks after it commences, the mortality being at least 50 per cent where remedial measures are not adopted.

Poisoning manifests itself in not less than three weeks from the beginning of feeding. The suddenness of the attack is such that it is often difficult to observe symptoms. In many cases pigs that are apparently well in the evening are found dead in the morning, and often the most careful watching fails to show any indications of indisposition. Where symptoms are present, those most characteristic seem to be disorder of respiration, which is manifested by quickened breathing, coughing, or hiccough. Failing appetite usually calls the attention of the feeder to the approach of danger. Seldom more than two days intervene between the first symptom and death. Postmortem examination shows congestion of the lungs and often the presence of fluid in the chest cavity. Dinwiddie[a] found an intense congestion of the liver and kidneys and large quantities of fluid in the chest cavity. He gives the immediate cause of death as suffocation due to the pressure on the lungs of the fluid which accumulates in the chest cavity. He suggests an alteration in the composition of the blood as the primary effect of cotton-seed meal poisoning.

The nature of the poisonous property of cotton-seed meal is not yet known. It is not even definitely settled whether it is of the nature of a toxin, for results are contradictory whether the amount of cotton seed or cotton-seed meal is more important than the length of time the feeds are given. The only treatment possible is an instant change of feed as soon as symptoms of poisoning appear. Cotton seed should be taken out of the ration and the pigs given roots, green feed, or a run on good succulent pasture. If not too late, they will be entirely well in a week.

While some experimenters have reached results which lead them to have a small appreciation of its value for feeding purposes under any circumstances, others have reached the conclusion that, if some means can be devised to prevent poisoning, cotton seed and cotton-seed meal are feeds of great value. The Kentucky, Wisconsin, Iowa, Kansas, and Oklahoma stations have published results which show that cotton-seed meal has considerable value for feeding pigs, if death losses can be averted. At the Wisconsin Station[b] pigs on a cotton-seed meal ration required 5 per cent less feed than those on a ration to which oil meal was added. At the Iowa Station[c] pigs on a ration of which 1 pound daily was cotton-seed meal made better gains than others on a ration one-half pound of which was cotton-seed meal, and better than pigs on rations in which there was no cotton-seed meal.

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[a] Bul. No. 76, Arkansas Expt. Sta. [b] Eleventh An. Rpt. [c] Bul. No. 28.

At the Kansas Station[a] six pigs that had been stunted by being fed corn meal or ground wheat exclusively were placed on rations of corn meal three-fourths, cotton-seed meal one-fourth, and equal parts of these meals. The effect is described as "magical" and immediate; the pigs began to gain in weight at once, and those receiving the greater amount of cotton-seed meal made the greater gains. No other feed was given, and the feeding was satisfactory until the forty-fifth day of the experiment, when the first pig died.

The Oklahoma Station has made an extensive study of the possibility of feeding this by-product so that good returns may be obtained with little or no danger from poisoning. The conditions under which it has been found that cotton-seed meal may generally be fed safely are (1) where pigs have access to range and plenty of green pasture, and (2) where periods of cotton-seed meal feeding of three to four weeks' duration without pasture are alternated with a period on pasture or on a ration from which the cotton-seed meal has been omitted.

Following up this system, the Oklahoma Station has conducted three experiments. In the first trial, in 1900, the alternating method was tried with 17 thrifty shoats of various sizes.[b] They were put on a ration composed of one-fifth cotton-seed meal and four-fifths Kafir-corn meal and had the run of a large paddock, where they got a little green stuff. The trial began March 22. For twenty-seven days the cotton-seed meal ration was fed; then for fourteen days Kafir-corn meal alone, next fourteen days on one-fifth cotton-seed meal and four-fifths Kafir-corn meal, then seven days without the cotton-seed meal, closing with five days on the original ration. "None of the pigs had died, and all made very fair gains on a moderate amount of grain." At the close of this trial part of the pigs were sold and the rest continued on the cotton-seed meal ration, with which the trial closed (one-fifth cotton-seed meal and four-fifths Kafir-corn meal). They were fed on this ration without change until July 14 with the loss of 1 pig only.

In the second trial of the same year 16 stunted shoats, about a year old and averaging 79 pounds, were used. For twenty-six days from April 12 they were hurdled on wheat and fed a light ration of one-fifth cotton-seed meal and four-fifths Kafir-corn meal. There was no ill effect from the grain ration. The gains averaged 0.96 pound per head daily and were made economically. On May 8 the pigs were taken from the wheat and fed the same grain ration in a lot for twenty-one days with no serious results, making an average daily gain of 1.71 pounds at the expense of 307 pounds of grain for 100 pounds gain. Five of the largest were sold after forty-seven days' continuous feeding on a cotton-seed meal ration.

The 11 pigs remaining were then given range and green feed and

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[a] Bul. No. 53. [b] An. Rpt. 1900–1901.

the same grain ration continued. The gains made were satisfactory. There were no losses, and they were sold on July 14, after ninety-three days' continuous feeding on a cotton-seed meal ration.

In 1901, 16 uniform grade Poland China shoats, farrowed late in the previous fall, were used.[a] They were about eleven weeks old at the beginning of the experiment and averaged about 47 pounds in weight. The experiment began January 11. The pigs were divided into four lot of 4 each. Each lot was given an open pen 9 by 24 feet and had a space 8 by 8 feet in an inclosed piggery. Cob charcoal, wood ashes, and salt were always accessible, water only was given to drink, and the grain was mixed with water into the form of a thick slop just before feeding. From January 14 to April 1, 2 pounds of sugar beets were allowed each pig daily. The pigs were fed as follows: Lot I received corn meal only to April 5, then a mixture of one-fifth cotton-seed meal and four-fifths corn meal for four weeks, closing with two weeks on corn meal; Lot II received one-third corn meal and two-thirds wheat middlings; Lot III received one-fifth cotton-seed meal and four-fifths corn meal; Lot IV received one-fifth cotton-seed meal and four-fifths corn meal for four weeks, then corn meal for two weeks, next the cotton-seed meal mixture for four weeks, then back to corn meal only for two weeks, and alternating in this manner until the experiment closed.

The only signs of lack of appetite were in Lot I, where exclusive corn-meal feeding proved rather severe for such young pigs, and in Lot III, where a dullness of appetite was noticed for about two weeks. This was only temporary. One pig in Lot IV died on February 15, one week after it had been taken from the cotton-seed meal ration and placed on corn meal, and 2 pigs in Lot III died on February 20, after they had been on a cotton-seed meal ration continuously for forty days. "No further losses occurred, * * * and the pigs thrived and made good gains." One pig in Lot IV showed symptoms of sickness, but recovered.

After April 5 Lot I was given the same management and feed as Lot IV, but there were no injurious results. On the contrary, their gains increased. This was also noticed with Lot IV. During the periods that the hogs were on a straight corn-meal ration, except during the closing period, when their greater maturity enabled them to make use of a more carbonaceous ration, the gains were light and expensive, but when the cotton-seed mixture was resumed the gains were large and economical, disregarding the effect of loss by death.

The pigs which were fed cotton-seed meal and which survived made much better gains than those on corn meal only, but somewhat less than those on corn meal and middlings. The cost of the cotton-seed meal lots was the least in the experiment.

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[a] Bul. No. 15, Oklahoma Expt. Sta.

Burtis and Malone suggest that had the cotton-seed meal lots been running on green pasture from the beginning of the experiment no losses would have occurred. They also suggest the probability that a ration of one-tenth to one-fifth cotton-seed meal may be fed for an indefinite time if pigs have the run of green pasture.

The Arkansas Station found a ration of cotton-seed meal and bran to be less dangerous than one of cotton-seed meal and corn meal, and that the addition of wheat bran to a cotton-seed meal ration gave better results than roots. The gains were not so satisfactory as in the Oklahoma tests. A notable feature of the Arkansas studies was the feeding of a native sow, carrying her third litter, on a ration of cotton-seed meal 1 part and bran 3 parts for eighty days before farrowing. She ate a total amount of 112 pounds of cotton-seed meal, which was 1.39 pounds daily and 0.8 per cent of the estimated initial body weight. The ration agreed with her, and there appeared to be no harmful effects on the fetal litter, it being farrowed safely, with no stillbirths.

The Kansas, Iowa, and Oklahoma results show that a cotton-seed meal ration is valuable if the cotton-seed meal is used in a moderate amount and for a limited time. The proportion of cotton-seed meal used in the Iowa test was about one-eighteenth and one-ninth of the total grain ration at the start and about one-tenth and one-fifth at the close. Up to the time the pigs began to die the gains of those on the heavier cotton-seed meal ration were the larger and more economical (1.4 pounds average daily gain and 343 pounds meal and 250 pounds milk per 100 pounds gain). The lighter ration was about equal in results to a lot of pigs on corn-and-cob meal, gluten meal, and buttermilk, that stood second to the heavy-fed lot. The two lots returned in pounds of gain per 100 pounds of dry matter in the feed (before deaths began) 31.1 pounds and 26.4 pounds, respectively, for the pigs on the heavy and the light rations. In the Kansas tests the gains before deaths commenced were also very economical; they varied in cost from considerably less than 300 pounds grain per 100 pounds gain in the case of the pigs that had been previously on the single-grain rations to 350 pounds grain per 100 pounds gain in the case of the sows.

The same is true of the Oklahoma tests. The feed required per 100 pounds gain was less than 400 pounds for the pigs which survived a period of one hundred and twenty-six days' feeding on cotton-seed meal, and the gains averaged over 1 pound daily.

The use of cotton-seed meal in the feed lot must be very carefully guarded, especially until the conditions under which it may be used without danger and the circumstances which govern the demonstration of its poisonous properties are more thoroughly understood. The feeding of the cotton-seed meal which the South produces is one of the greatest problems of agriculture in that section yet to be solved satisfactorily. It is not difficult to appreciate what may be gained if

some of this by-product, which has such high feeding and fertilizing value, and which is exported in such enormous quantities, can be converted into pork products, which are now largely imported from other States.

FEEDING PACKING-HOUSE BY-PRODUCTS.

The frugality of the modern meat packer has become almost proverbial. Less than twenty years ago the disposal of the offal of slaughtering was a problem, but at present there is very little waste, and the packer has actually come to regard the by-products as the principal source of profit in his business. The preparation of these by-products for use as animal feed is one of the later developments of this branch of the industry. Fertilizers have long been prominent in the sales, the material that enters into their composition being meat scraps, blood, bone, hair, intestinal contents, etc. The use of tankage, a by-product that has had its sale entirely as a fertilizer, is growing among pig feeders, and has been studied by the Indiana Station[a] and by the Iowa Station.[b] Beef meal is also a packing-house product, whose feeding value was studied along with that of tankage in the Iowa experiment.

Tankage is made from meat scraps, fat trimmings, scrap bones, etc., which are sent to a rendering tank and cooked under a steam-pressure of 40 pounds to the square inch. The grease is drawn off, and by different processes the residue is dried, ground, and packed for shipment. Occasionally pieces of the intestines and their contents, hair, etc., are found in tankage, which lessens its value as feed. Beef meal is prepared in a somewhat similar manner.

These by-products have a very high protein content, that of the tankage used in these tests being from 40 to 50 per cent and that of the beef meal used in the Iowa test showing 61.10 per cent protein. The fat content of the tankage was higher than that of the beef meal. In the Indiana test the largest and most rapid gain and the least feed requirement per 100 pounds gain was obtained by a ration of corn meal 5 parts and tankage 1 part; a ration of equal parts of corn meal and shorts 10 parts and tankage 1 part gave the cheapest gains financially. The tankage rations were better in all respects than a ration of corn meal only. In the Iowa test similar results were reached.

In the Indiana test the use of tankage lessened the amount of grain required per 100 pounds gain from 203 pounds to 175 pounds—from 38.9 to 33.5 per cent—showing tankage to be very profitable with the prices that were charged for grain in this instance.

In the Iowa test 140 pounds and 96 pounds, respectively, were saved by the use of tankage—30.4 and 20.8 per cent—not so good a record as obtained in Indiana. The difference between the money cost per

[a] Bul. No. 96. [b] Bul. No. 65.

100 pounds of the corn-fed and tankage-fed lots was also much less than in Indiana.

The condition of the pigs in the Indiana test was remarked upon. The tankage-fed pigs handled better, had finer, silkier coats, and ate with much more relish than those on corn alone. The corn-fed lot was conspicuous by reason of its poor condition.

At the conclusion of the Indiana experiments, the pigs that had been on corn meal were given a ration of 5 parts of corn meal and 1 part tankage for forty-nine days. There was immediate improvement in their appetites, the hair softened, and the skin handled better. There was a marked improvement in growth, which contrasted strongly with the gains made while on corn meal only.

Experimenters caution stockmen to use that tankage only which has been specially prepared for feeding purposes.

The Iowa test with beef meal seems to show that it, like tankage, is valuable in a pig's ration. The corn-meal fed lot made an average daily gain of 2.08 pounds, requiring 461 pounds feed for 100 pounds gain, and making gains at a cost of $5.10 per 100 pounds. Those fed beef meal made an average daily gain of 2.40 pounds, requiring 346 pounds grain and 65 pounds beef meal for 100 pounds gain, at a cost of $4.80 per 100 pounds gain. Sixty-five pounds of tankage thus saved 115 pounds of grain—nearly 25 per cent.

DAIRY BY-PRODUCTS.

The use of the by-products of the dairy and creamery (skim milk, buttermilk, and whey) is one of the most interesting subjects of study in pork production. The value of the milk is known on every farm, although it may not be fully appreciated, and anyone who has fed pigs knows the keen appetite that these animals have for milk and its products. In the neighborhood of many large dairies pork production has become a very prominent and lucrative branch of the dairy industry.

Regarding solely their chemical composition, the by-products of the dairy contain most of the indispensable feeding constituents of the milk from which they are produced.

The residue from the separation of cream (skim milk) and that from churning (buttermilk) leave two products that contain practically all the protein and carbohydrates of the whole milk. In cheese making, the whey that is left is the least valuable of the dairy by-products, the greater part of the casein and fat of the milk being retained in the cheese. While whey is by no means worthless for feeding purposes, it can readily be seen that if skim milk and buttermilk have higher feeding values for pigs than whey, butter making and pig feeding will more profitably accompany each other than will cheese making and pig feeding. These by-products supply growing

material to young animals and provide an excellent nitrogenous balance in the fattening ration. The constituents that remain in the milk after skimming and churning are the most expensive ones, considered from the standpoint of feeding and fertilizing value, and it is largely due to this fact that dairy farming is so often a profitable business when conducted in a thorough manner.

The value of dairy by-products is not alone in their nitrogenous character. They have an effect on the digestion that brings results out of all proportion to their nutritive value and are more valuable than the nitrogenous grains to balance rations.[a] Where pigs have been for a long time on a monotonous ration, such as corn meal alone, they lose appetite, become listless and sick, and so make very unsatisfactory gains. If skim milk is given, even in very small amounts, an immediate change for the better is noticed—appetite returns and the pigs begin to gain rapidly in weight. As already stated, the gain in weight is out of all proportion to the actual amount of nutrient material in the milk, and this peculiarity has been remarked upon, not only when pigs are fed as indicated above, but also when pigs are fed a varied grain ration and skim milk in comparison with others on the grain ration only. Just why dairy by-products have this effect is not exactly known, but the suggestion has been made that they keep the digestive system in better order, and thus enable the animal actually to digest a greater percentage of his feed. The same fact has been noticed when roots and green feed are fed. Pasturing on rape, alfalfa, or the grasses probably has a similar though less marked effect.

Snyder's investigations at the Minnesota Experiment Station[b] seem to show that the action of milk is actually to make the feed more digestible. He found that milk rendered soluble from 1 to 3 per cent of the total insoluble proteids of wheat flour, and attributed its action to the soluble ferment, or enzyme, which is normally present in milk. Some milks were found to have a greater digestive action than others.

The effect of dairy by-products on the carcass is one of the most important results of such feeding. It is generally admitted that, while excellent hams and bacon may be produced without dairy by-products, the use of these by-products will result in pork of a more nearly uniform high quality.

The economy of skim-milk feeding in connection with grain has been repeatedly demonstrated. According to Henry,[c] the average of results of the Danish experimenters show that when so fed 600 pounds of skim milk has a feeding value about equal to 100 pounds of grain. At the Wisconsin Station the average of nineteen trials with propor-

[a] Bul. No. 63, Maryland Expt. Sta.
[b] Buls. Nos. 74 and 86.
[c] Feeds and Feeding, p. 572.

tions of milk to grain varying from 1 to 9 pounds of milk for each pound of grain fed show a value of 475 pounds of skim milk for 100 pounds of meal.

Extensive experiments at the Central Experimental Farm of Canada show a value for milk of about 600 pounds for 100 pounds of grain.[a]

The value of milk with grain is also shown when rations of grain alone and of grain and milk are compared. The average of a series of experiments at the Utah Station[b] showed that where grain alone was fed in 5 tests the pigs made an average daily gain of 0.91 pound, consuming 421 pounds of dry matter per 100 pounds of gain; in 8 tests, where a grain-and-milk ration was fed, the average daily gain was 1.27 pounds and the dry matter per 100 pounds of gain 334 pounds. Results at the Tennessee Station[c] gave an average daily gain of 1 pound for pigs on a corn-meal ration, with 416 pounds dry matter consumed per 100 pounds of gain; when corn meal and skim milk were fed, the average daily gain was 2.3 pounds and the dry matter per 100 pounds of gain 293 pounds. Two years' additional tests at the same station[d] showed an average daily gain of 0.50 pound and 410 pounds of gain when corn meal only was fed; when corn meal and skim milk were fed, the average daily gain was 1.35 pounds, and the feed eaten per 100 pounds of gain 160 pounds grain and 1,190 pounds milk. The cost of 100 pounds of gain was $5.80 when no milk was given; when milk was fed it was $4.60. The profit for the group (value of the manure and cost of care not being considered) was $1.05 for the corn-meal-fed lots and $4.96 for those fed milk.

Although skim milk is of great value when fed with grain, especially corn meal, it is not a satisfactory feed by itself. Where attempts have been made to maintain pigs on skim milk alone the gains were small and the returns for the milk fed less than when grain was fed in connection with it. With grain at 75 cents per 100 pounds, Linfield[e] estimates the return for skim milk at 17 cents per 100 pounds when grain and milk are fed to pigs and only 10 cents per 100 pounds when milk is fed alone.

The quantity of milk may be greater with pigs suckling the dam or newly weaned than with older shoats, but young pigs should not be maintained exclusively on skim milk. The Tennessee Station, feeding pigs averaging from 75 to 100 pounds on rations composed of mixed grain and milk in varying proportions from 1:3 to 1:12, found the best results when the ratio of grain to milk was 1 to 3. The rations containing the large amount of milk were found to be unduly expensive. At the Cornell Station[f] two experiments showed the best

[a] See Bul. No. 47, p. 143, Bureau of Animal Industry.
[b] Bul. No. 57.
[c] Vol. XV, Bul. No. 1
[d] Vol. XVI, No. 3.
[e] Bul. No. 57, Utah Expt. Sta.
[f] Bul. No. 199.

results when this ratio was 1:3 and 1:2.5; in two others proportions of 1:6.7 and 1:6.2 showed the best results.

When an unlimited supply of milk is available the Hatch Station[a] recommends the following ration for young and growing pigs weighing from 20 to 180 pounds:

Rations for growing pigs.

Weight of pigs.	Rations.
20 to 60 pounds	3 ounces of corn meal to each quart of milk.
60 to 100 pounds	6 ounces of corn meal to each quart of milk.
100 to 180 pounds	8 ounces of corn meal to each quart of milk.

The following rations may be used where the milk supply is in limited amounts:

Rations for growing pigs.

Weight of pigs.	Rations.
20 to 180 pounds	3 ounces of corn meal, wheat, rye, or hominy meals to each quart of milk, and then gradually increase meal to satisfy appetites.
20 to 60 pounds	Milk at disposal, plus mixture of one-third corn meal, one-third wheat bran, and one-third gluten meal to satisfy appetites.
60 to 100 pounds	Milk at disposal, plus mixture of one-half corn meal, one-fourth wheat bran, and one-fourth gluten meal to satisfy appetites.
100 to 180 pounds	Milk at disposal, plus mixture of two-thirds corn meal, one-sixth wheat bran, and one-sixth gluten meal to satisfy appetites.
20 to 60 pounds	3 ounces of corn meal to each quart of milk, and 4 ounces of gluten feed as a substitute for quart of milk.
60 to 100 pounds	Milk at disposal, and mixture of one-half corn meal and one-half gluten feed to satisfy appetites.
100 to 180 pounds	Milk at disposal, and mixture of two-thirds corn meal and one-third gluten feed to satisfy appetites.

Whey also has great value as an adjunct of the grain ration. The average of four experiments at the Ontario Agricultural College gives a feeding value about one-eleventh that of corn; that is, 1,100 pounds of whey are worth 100 pounds of grain when fed in a grain ration. According to the Ontario results, souring does not seriously impair the feeding value of whey. The four experiments show very nearly as good results from sour as from sweet whey. The injurious effects which frequently follow whey feeding and are manifested by stiffening of the joints and rheumatism were evident among the pigs fed sweet whey, but were entirely absent from those fed on the sour whey.

The cost of handling feed and caring for live stock has not been very extensively discussed in the literature on the subject. Where

[a] Eleventh An. Rpt. (Mass.)

only a few pigs are fattened annually the feeder does not notice the effect of wasteful methods, but where large numbers are fed a minimum of waste in feeding and the highest efficiency of labor are absolutely essential to profitable results. Dairying and pig feeding are so intimately related that Linfield's[a] investigations on this subject are interesting. Correspondence with various creameries in Utah, where large numbers of hogs are fed, are summed up as follows:

One creamery reports that one man would feed 1,000 hogs, clean all the pens each day, and draw the grain feed from the mill 2 miles distant. Another says that one man does all the work of feeding and cleaning out the pens for 500 hogs in five hours each day. The wages paid in each case was about $1 per day.

At both creameries the hogs are purchased when weighing from 50 to 100 pounds each, though some few are heavier. The hogs are crowded from the start, and at most not more than one hundred days are required to fit the hogs for market, and in this time 100 to 125 pounds have been added to the live weight of each hog.

By putting all of the above figures together we find that it costs five hours' labor or 50 cents to look after 500 hogs for one day, or $50 to look after 500 hogs for one hundred days. This is 10 cents for one hog for one hundred days, or for 100 pounds gain, which gives one-tenth of a cent as the labor cost of producing 1 pound of live weight of hog. It is thus evident from the results of these practical men that when handled in large numbers, as hogs may be at a creamery, the labor is a very small item in growing the hogs. If the value of the gain was reckoned at 4 cents per pound, the labor cost of producing the pork was but 2½ per cent of its selling price.

Lest these results be misleading, Linfield calls attention to the fact that the conditions were almost ideal for the greatest economy—the hogs were "short fed" and all feeding appliances and pens were so arranged as to have in view the greatest possible saving of labor. At another creamery, where the hogs were raised on the place and fed until they were fifteen months old and the accommodations were not so good, the cost reported was as large for 300 hogs as the others reported for 1,000 head. It is pointed out that on the average farm, where the number of animals is much smaller and milk must usually be hauled back to the farm, the labor cost will be very much greater.

PASTURE AND PASTURE SUBSTITUTES.

PASTURE.

There is a marked similarity between the effect of dairy by-products and pasture on the efficiency of the grain ration of pigs, which is generally out of proportion to the nutrient value of the amount consumed of these supplementary feeds, and is to be accounted for only on the theory that the digestive apparatus is kept in better order by their use and made more efficient. Except when epidemics are prevalent, and the possibility of contact with contagion induces the feeder to keep his pigs confined, an ample range on pasture will keep them in healthy condition and enable an amount and rate of gain which well

[a] Bul. No. 57, Utah Expt. Sta.

repays for the use of the pasture. The Utah Station[a] has recently published results which confirm previous investigations on the subject. Four years' work shows that pigs on grain alone ate 4.05 pounds of feed daily and made an average daily gain of 0.94 pound, eating 430 pounds of grain for 100 pounds gain. The pigs on pasture with grain ate 4.72 pounds of grain daily, made an average daily gain of 1.21 pounds, and ate 385 pounds of grain for 100 pounds gain. The total gains average 33 per cent greater for the pigs on pasture than for those on grain alone. The average daily gains were nearly 29 per cent greater, and there was a saving of more than 10 per cent in the feed required for 100 pounds gain for the pigs on pasture. The larger amount of feed eaten by the pigs on pasture is also noteworthy, for a large consumption of feed generally leads to large gains. Two earlier tests at the same station by Linfield[b] were designed to compare the relative merits of pasture and pen feeding when pigs were fed on milk alone, on grain alone, and on milk and grain. The only pigs that showed better results in pens than on pasture were those on grain and milk. Those receiving grain alone on pasture gave very much larger gains, required less feed per 100 pounds gain, and ate more feed than those receiving grain alone in pens. Linfield suggests that either the exercise or the feed obtained by the run on pasture gave these pigs greater appetite and enabled them to digest a greater amount of feed daily. The fact that neither of the other lots showed a marked advantage from pasture might be explained by the skim milk in the ration. It is perhaps a safe proposition that in feeding pigs the best results will follow the use of dairy by-products, roots, or pasture in connection with grain, but that it is superfluous to combine two of these supplementary feeds, as their action on the digestive system seems to be similar. When attempts are made to prevent disease, however, the advantage of ample exercise must not be overlooked.

Pasture is hardly, if at all, a maintenance ration, and as the profits in feeding come from a continuous gain until the animals are sold, such a ration should be resorted to only under the pressure of extreme necessity, when the saving of grain is imperative. According to Henry,[c] no station has shown that pigs can be successfully maintained on pasture alone, if a former test by Mills at the Utah Station be excepted. Two later tests at this station by Foster and Merrill,[a] for periods of over 100 days, where four lots of pigs were pastured on alfalfa or mixed grasses, showed actual losses with two lots and very slight gains with the others, the average daily gain amounting to 0.189 pound in one case and 0.059 pound in the other. The effect of this method of feeding on the appearance of the pigs was very marked; in the 1898 test it was particularly commented upon. "The plump

[a] Bul. No. 70. [b] Bul. No. 57. [c] Feeds and Feeding, pp. 578, 579.

rounded forms gave place to large, coarse frames and large stomachs. At the end of the experiment they looked very much larger than at the beginning, but the scales failed to show any gains. What is said above would also apply to the mixed-pasture set, only in that case the eye was not so badly deceived—small gains were made." In 1899 pigs that were receiving small amounts of feed, either milk or grain in addition to pasture, were found to have made gains very nearly in proportion to the amount of extra feed given, which Foster and Merrill regard as evidence that the pasture supplied enough feed for maintenance only.

Tests at the Oklahoma Station[a] showed a total gain of 68 pounds for 4 pigs in eight weeks—17 pounds each—where pigs were on pasture alone, while 4 others on pasture with a grain ration gained 324 pounds in the same time, an average of 81 pounds.

A sow with a litter of 5 pigs was in the same lot with the grain-fed pigs. The sow gained 61 pounds in thirty-five days, when she was removed. Her 5 pigs made a total gain of 146 pounds in the first five weeks and 96 pounds during the succeeding period of three weeks. The grain fed these pigs amounted to only 221 pounds per 100 pounds of gain.

In addition to tests mentioned in a preceding paragraph, experiments by Linfield[b] at the Utah Station show that when pigs are receiving a grain ration with dairy by-products the addition of pasture is unnecessary and adds nothing to the effectiveness of the ration or the gains made. The average of four experiments shows average daily gains of 1.03 pounds where pasture was allowed; these pigs consumed 1,544 pounds milk and 236 pounds of grain per 100 pounds of gain. The pigs without pasture consumed 1,827 pounds milk and 218 pounds of grain per 100 pounds of gain, making an average daily gain of 1.06 pounds. The amount of feed consumed daily by the pigs on pasture was somewhat less than in case of those without it. The only advantage noticed from the pasture was in the case of two lots which received skim milk only, but no grain. In the experiments where grain was fed no advantage accrued through the use of pasture, except that the pasture lots consumed nearly 300 pounds less milk per 100 pounds gain than those in pens. At 15 cents per 100 pounds, this means a difference of 45 cents per 100 pounds of pork made. The difference in grain fed was nearly 20 pounds per 100 pounds of pork made in favor of the pen-fed lots.

These results are evidence in support of the idea that the effect of dairy by-products and succulent feed in the ration is similar, and that to get the greatest amount of gain at the least expenditure of feed only one of the supplementary feeds is necessary; that the addition of pasture to a ration which already contains a large amount of dairy

[a] An. Rpt., 1898–99. [b] Bul. No. 57.

by-products is superfluous, and that the only advantage to be gained by such a method of feeding is the exercise obtained by the pigs on pasture.

GREEN SUBSTITUTES FOR PASTURE.

The lack of a permanent pasture should not deter the prospective pig feeder from engaging in the business. A prominent feature of the recent development of the industry has been the increasing use of succulent feeds, such as cereals, rape, vetches, cowpeas, sorghum, etc., which yield large amounts of feed per acre and also enable the feeder to grow his season's pasturage on a small amount of land by means of a succession of crops. Not only does this make successful pig feeding when only a limited amount of land is available, but, by restricting the amount of range allowed the hogs, removes to a large extent the objection to pasturage when exposure to disease is to be feared, yet permits the advantages of exercise and succulent feed. Rape has been most generally used for this purpose, and experiments have been reported recently by the Utah[a] and Alabama[b] stations and by the Central Experimental Farm of Canada[c]. The gains at the Canadian station were particularly good, averaging 1.27 pounds daily, the pigs eating 238 pounds of grain per 100 pounds of gain. In the Alabama test the average daily gain was 0.56 pound and the feed per 100 pounds of gain was 238 pounds. In the Utah test the average daily gain was 0.204 pound and the feed per 100 pounds gain 490 pounds.

At the close of the Alabama test the pigs were placed on second-growth rape for three weeks. They grazed one-sixth acre, eating 168 pounds corn meal and making a gain of 82 pounds, which was an average daily gain of 0.98 pound, at a cost of 205 pounds meal for 100 pounds gain. Assuming that 500 pounds of grain alone are required for 100 pounds gain, Duggar estimates the amount of the pork produced per acre from the first and second growth rape together at 512 pounds, worth at that time $20.48.

Seven shoats, averaging 41 pounds in weight, were on rape at the same station for four weeks during the late spring. They received some corn meal in addition. During the first two weeks the rape was fed to the pigs in the pens; during the remainder of the time they were hurdled. They ate 318 pounds of corn meal. The total gain in weight for the four weeks was 103 pounds, an average daily gain of 0.53 pound, 310 pounds of grain and 4,050 square feet of rape being required to produce 100 pounds of gain.

Compared with clover, the Wisconsin Station[d] found in two tests that pigs receiving a grain ration and hurdled on rape made larger and

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[a] Bul. No. 70.
[b] Bul. No. 122.
[c] An. Rpt., 1900.
[d] Sixteenth and Seventeenth An. Rpts.

more economical gains than those on the same grain and hurdled on clover.

The same station[a] fed two lots of pigs on rape alone for two weeks. Two lots of 18 pigs each were taken from rations composed of grain exclusively, grain and clover, and grain and rape. They were given nothing but rape. They fed nearly all day, appeared contented, and scoured but little, but 25 of the 36 lost in weight during the two weeks they were on rape, and only 4 made gains. The total loss on 36 pigs was 60 pounds, or at the rate of 1.66 pounds per pig. The 6 pigs that had been on an exclusive grain diet lost 18 pounds, or 3 pounds each. The 8 pigs that had been on grain and clover lost 19 pounds, an average of nearly 2.33 pounds each, and the 22 pigs that were taken from a grain and rape diet lost 33 pounds, or 1.5 pounds each.

PASTURE SUBSTITUTES IN SOUTHERN STATES.

One of the most promising features of animal husbandry in the South is the large range of forage crops at command. The hog raiser is particularly benefited by these crops, many of which may be sown annually and used as substitutes for pasture. The most common Southern grazing crops for pigs are peanuts and cowpeas. Both are very highly nitrogenous and therefore are good crops to use as a supplement to a ration composed of corn, rice products, or other carbonaceous feeds. In addition to cowpeas and peanuts, chufas,[b] sorghum, soy beans, velvet beans, rape, sweet potatoes, etc., are used for pig grazing. The method of grazing is usually that of hurdling; that is, the pigs are inclosed on a small part of the field by means of portable fences. These fences are moved to ungrazed parts of the field as the plants are eaten. Nearly all the efforts of the stations have been confined to demonstrations of the feasibility of pig feeding in the South and the possibilities of grazing the forage crops which abound in that section. The Arkansas Station[c] made pork at the rate of 1,252 pounds per acre from peanuts, 592 pounds per acre from chufas, and

[a] Seventeenth An. Rpt.

[b] Chufas are coarse plants belonging to the sedge family. Two species are used in the manner here mentioned—*Cyperus rotundus* and *C. esculentus*. According to Gray *C. rotundus* is found in sandy fields from Virginia to Florida and Texas, and is occasionally met with in the neighborhood of Philadelphia and New York City. *C. esculentus* is found in low grounds, along rivers, etc., from New Brunswick to Florida and west to Minnesota and Texas. This is the species more commonly used as feed for hogs.

These plants form small tubers which enable them to spread rapidly and form a thick, matted growth, each tuber being capable of producing a plant. The tubers are relished by hogs, but the plants are of questionable value, as it is almost impossible to eradicate them when once established, especially in sandy soils. Botanists do not advise planting them in soil that can be used for any other purpose.

[c] Bul. No. 54.

436 pounds per acre from corn, estimating the yield of corn at 30 bushels per acre. The forage crops were hurdled and the corn fed dry on the ear. In other tests at the same station both peanuts and chufas gave especially good gains. The Alabama Station[a] grazed 6 Poland China pigs on peanuts, with some corn in addition. The lot made a gain of 380.7 pounds in six weeks on an area of about one-sixth acre and ate 373 pounds of corn. Estimating corn at 40 cents per bushel and pork at 3 cents per pound, this is a return of $18.34 per acre for peanuts from this method of feeding.

On a portion of the field which was not pastured the peanuts were dug and yielded at the rate of 62.6 bushels (1,565 pounds) of dry nuts per acre. From this the total feed required to produce 100 pounds gain was estimated as 140 pounds of peanuts and 190 pounds of corn—a total of 330 pounds of concentrates, with vines eaten not estimated.

This station estimates the value of the return from peanuts in pork at $18 per acre, and states that the same land with the same fertilizers would not produce over 200 pounds of lint cotton per acre, which would be worth $10 or $12, with cotton at 5 or 6 cents per pound, while the expense of cultivating the cotton would be much greater.

In a later experiment Duggar[b] penned a litter of nine-weeks-old pigs on a two-thirds stand of Spanish peanuts just after weaning. They were on this pasture from November 4 to December 23, and ate 162 pounds of corn meal for 190 pounds gain in addition to grazing about five-sixths of an acre of peanuts. At 4 cents per pound for pork, and making allowances for the grain eaten, the return per acre for the peanuts was $10.04.

In another test[b] a sow and her litter of 9 pigs were fed from September 30 to November 4 on corn meal, skim milk, and Spanish peanuts from one-fourth acre of land. They ate 355 pounds of corn meal and 921 pounds of skim milk. The sow and pigs gained a total of 236 pounds. At 4 cents per pound for pork, valuing corn meal at $1 per 100 pounds and skim milk at 25 cents per 100 pounds and estimating 325 pounds of skim milk to be worth 100 pounds corn meal, the return per acre for the peanuts was $17.28.

In another test[b] 7 shoats, averaging nearly 100 pounds, were penned on Spanish peanuts from October 11 to November 2 and fed some corn meal. They made a total gain of 225 pounds, eating 286 pounds of corn meal and grazing the peanuts on 0.47 acre, requiring only 127 pounds of corn meal for 100 pounds gain. With the usual allowances, the return per acre for the peanuts in this test was $18.02.

In another test[b] 7 shoats were taken from corn meal, cowpea meal, and sorghum and placed on Spanish peanuts and corn meal for four weeks. They ate 333 pounds of corn meal and grazed 10,593 square

[a] Bul. No. 93. [b] Bul. No. 122, Alabama Expt. Sta.

feet of peanuts, making a gain of 121 pounds, which was at a cost of 273 pounds grain for 100 pounds gain. The value per acre of the peanut pasture was estimated, by the usual methods, at $9.

Some of these pigs were continued by hurdling on peanut pasture and were given some grain in addition for five weeks longer. In this period the return per acre for the peanuts were estimated at $9.88.

In another test[a] a litter of 7 Poland China pigs, averaging 28 pounds in weight, were hurdled on Spanish peanuts just after weaning. The pasturing continued six weeks and no grain was fed. The total gain was 157 pounds, an average daily gain of 0.53 pound. The area grazed was 13,887 square feet, and the return per acre, with pork at 4 cents per pound, was $20.12.

The Alabama Station[b] fed one lot of pigs on a peanut field which was a poor stand, giving some corn meal additional; another lot had nothing but the peanut pasture, and a third lot corn meal only. There were 3 pigs in each lot, and they were of rather ordinary feeding qualities. In four weeks the lot on peanuts and corn meal gained 38.6 pounds, those on peanuts alone gained 21.1 pounds, and those on corn meal lost 5.1 pounds. The lot on peanuts and corn meal ate 206 pounds of corn per 100 pounds gain and grazed 2,025 square feet planted in peanuts. "This is at the rate 840 pounds of growth from 1 acre of peanuts (with less than half a stand) and 1,710 pounds (35.6 bushels) of corn meal. With pork at 3 cents per pound and corn meal at 40 cents per bushel of 48 pounds, this is a gross return of $25.20 and a net return (after subtracting the value of the meal) of $10.94 per acre of peanuts."

The pigs on peanuts only "pastured an area of 3,517 square feet, and the gain made was 21.1 pounds, which is at the rate of 261 pounds of pork per acre. At 3 cents per pound gross for pork, this gives a value of $7.83 to the acre of peanuts on which there was only half a stand of plants."

The Alabama Station estimates the value of peanuts in pork production at $12 to $20 per acre, the higher returns being made where corn meal supplements the peanut pasture.

In another test at the Alabama Station,[a] pigs grazing peanuts, with a half ration of a mixture of corn meal 2 parts and cowpea meal 1 part, pigs grazing peanuts alone, and pigs grazing chufas with the half-grain ration mentioned, were compared with pigs on a full ration of the same grain mixture, fed in a bare lot. All lots but those grazing peanuts alone made very good gains. The pigs on peanuts and grain made an average daily gain of 1.50 pounds, requiring 188 pounds grain for 100 pounds of gain. Those on chufas and grain made 1.46 pounds

[a] Bul. No. 122, Alabama Expt. Sta. [b] Bul. No. 93.

average daily gain and ate 192 pounds grain per 100 pounds gain. The grain-fed pigs gained 1.31 pounds daily per head, eating 431 pounds of grain per 100 pounds of gain. The pigs on peanuts only made an average daily gain of only 0.46 pound, showing that the best results may be had when grain is fed with peanuts. The return per acre of peanuts and chufas, with pork at 4 cents per pound, was estimated, where grain was fed, at $9.56 and $9.62, respectively. The pigs on peanut pasture without grain returned only $3.03 per acre for the crop. At the rate of gain made in this experiment it is estimated that with these rations 1 acre of the grazing crop would provide feed for a 100-pound shoat as follows: Peanuts and grain ration, eight hundred and fifty days; chufas and grain ration, eight hundred and twenty-seven days; peanut pasture alone, four hundred and sixty-three days.

The value of sorghum and cowpeas as grazing crops was investigated by the Alabama Station.[a] One lot was hurdled on drilled sorghum which was in the dough and ripening stages and received a half grain ration of a mixture, by weight, of corn meal 2 parts and cowpea meal 1 part. Another was placed in a pen in which sorghum was growing and had, in addition, enough ripe Spanish peanuts to constitute a half ration of peanuts. A third was hurdled on drilled Whippoor-will cowpeas on which part of the pods were ripe, and received no grain. The fourth was confined in a bare pen and given the grain mixture given Lot I in such amount as the pigs would eat up clean.

The results were not very satisfactory for grazing on sorghum or on cowpeas without a supplementary grain ration. The waste of feed in the cowpea lot was very great, large numbers of the ripe pease falling to the ground and sprouting. Previous work at the Alabama Station has shown more satisfactory results when grain was fed in conjunction with the cowpea pasture.

Duggar[a] notes another experiment with sorghum grazing, in which there was a large waste of feed, although grain was fed. Seven shoats were on the sorghum from June 24 to September 2, 1899, and received at the same time about 1.5 pounds per head daily of a mixture of equal parts, by weight, of cowpea meal and corn meal. The pigs grazed 15,374 square feet of sorghum and 8,380 square feet of second-growth sorghum. They ate 812 pounds of grain, or 360 pounds of grain per 100 pounds of gain. Making allowances for the value of the grain fed, the return per acre of sorghum, with pork at 4 cents per pound, was estimated at $7.80. The second-growth sorghum produced only about one-half as much feed as the first growth. Large quantities of the sorghum were trampled under foot, and when some of it was cut and carried to the pigs a given area lasted much longer than when they were turned in to graze. Duggar suggests that when labor is

[a] Bul. No. 122, Alabama Expt. Sta.

cheap and abundant or a corn harvester is available soiling sorghum will be the more profitable method of feeding.

An earlier experiment at the Alabama Station[a] gave more profitable results from a ration of grain and cowpea pasture. One lot of pigs had corn only; another was hurdled on cowpeas about half matured at the beginning of the experiment and given corn. The cowpeas yielded about 13 bushels of pease per acre. The pigs on corn alone made an average daily gain of 0.36 pound, eating 586 pounds of grain per 100 pounds of gain. Those on cowpea pasture with corn made an average daily gain of 0.97 pound, eating 374 pounds of corn per 100 pounds of gain.

The pigs were pastured on an area of 7,280 square feet, or about one-sixth of an acre. Valuing pork at 3 cents per pound and corn at 40 cents per bushel, the return for cowpeas per acre was estimated at $10.65, not including the value of the manure made. By pasturing, 277 pounds of corn were saved per 100 pounds gain, and therefore an acre of cowpeas would replace 1,662 pounds of corn, using this test as a basis.

The Maryland Station[b] fed a number of pigs on cowpea pasture and concluded that cowpeas are well adapted to pigs about three months old. The older pigs that had been highly fed and had always been kept in a pen evidently had lost their rustling ability and did not thrive so well on cowpeas.

The abundant variety of forage plants at the command of Southern farmers led Duggar to suggest a succession of grazing crops which could be planted in the milder portions of the South, so that pasture would be available from January to December. The following table shows the crops suggested, using the results of investigation by the Alabama Station as a basis; it is said that other forage crops will be added as they are tested, such as alfalfa, pumpkins, artichokes, and soy beans:

Succession of forage crops.[a]

Months to be used.	Crops.
January and February	Fall-sown rape and chufas.
March 1 to April 15	Fall-sown rape, vetches and oats, rye, wheat, etc.
April 16 to May 1	Vetches and oats, crimson clover, oats, and wheat.
May	Spring-sown rape, vetches and oats, wheat, and the usual pastures.
June	Spring-sown rape, stubble fields, turf oats, and the usual pastures.
July and August	Sorghum, early varieties of cowpeas, and the usual pastures.
September, October, and November	Spanish peanuts, cowpeas, sweet potatoes, and sorghum.
December	Chufas and fall-sown rape.

[a] Bul. No. 122, Alabama Expt. Sta.

A disadvantage of grazing pigs on peanuts or chufas, the effects of which must be guarded against by the Southern feeder, is that the lard

[a] Bul. No. 93, Alabama Expt. Sta. [b] Bul. No. 63.

from such pigs has a very low melting point; the fat, therefore, makes the flesh soft, flabby, and undesirable in appearance, especially during the summer months. To obviate this difficulty the common practice of farmers is to use corn in finishing hogs which have had peanuts as the principal component of the ration. Recently the effect of cotton-seed meal on the fat has been investigated, with good results so far as increased firmness of the pork produced is concerned.

According to Bennett,[a] if good grade or purebred pigs are grazed on peanuts or chufas, either alone or combined, and if at the same time they are fed an amount of corn sufficient to full feed exclusively for four weeks, the quality of the pork and lard produced can not be distinguished in appearance from that of pigs fed on corn exclusively. Bennett[a] regards the use of more than this amount of corn as too expensive for the results obtained. He also reports that his results have shown that purebred pigs or good grades produce a firmer quality of pork and lard than scrubs. The range of individual variation in the melting point of lard from scrubs was much larger than that of the lard from grades and purebreds. Duggar,[b] however, states that in his experience, even when fed a month exclusively on corn, pigs formerly on peanuts made much more oily and soft pork and lard than those fed corn throughout the entire feeding period. This condition was noticeable even after cooking. "One month of exclusive corn feeding increased the firmness of pork made from animals previously fed on peanuts alone, but the improvement was not sufficient to make the flesh or the lard as firm as the same articles afforded by animals fed entirely on corn." Both Bennett and Duggar state that while exclusive peanut feeding injures the sale of lard and pork by making it soft and oily the cooking quality does not seem to be impaired.

It is also given as the experience of both these stations that feeding exclusively on corn for a month after the feeding on peanuts was stopped did not have an effect on the melting point of the fat that was appreciably different from that of hogs fed corn simultaneously with the peanut grazing. The melting point is lower in the case of immature pigs than with mature ones. The hardening effect of other feeds than corn and of combinations of these feeds with corn has been studied extensively by the Alabama Station,[c] where a pig that was fed a ration of one-third ground cowpeas and two-thirds corn meal was compared with pigs which had grazed sorghum, peanuts, or chufas, with and without grain. The melting point of the fat of the jowl was found to be 4.6° F. higher than in the case of pigs which had the same grain ration but had grazed peanuts and sorghum, and still higher than that from pigs which had grazed cowpeas. A number of experi-

[a] Bul. No. 65, Arkansas Expt. Sta.
[b] Bul. No. 93, Alabama Expt. Sta.
[c] Bul. No. 122.

ments show that a ration in which cotton-seed meal entered to the extent of one-fourth had a marked effect on the hardness of the fat.

PUMPKINS AND APPLES.

Farmers generally regard pumpkins highly as a fall pig feed. They are succulent, palatable, and nutritious, and, properly fed, give profitable returns. Experiments at three stations[a] where the utility of cooking pumpkins was studied, show that the practice added little to the efficiency of the ration. The gains from feeding were good in all cases and economically produced. Pigs fed on raw pumpkins and grain showed gains at a cost of 262 pounds of grain and 376 pounds of pumpkins per 100 pounds of gain where the pumpkins were fed raw, and 222 pounds of grain and 1,150 pounds of pumpkins for each 100 pounds of gain when they were cooked.

Three pigs, averaging 141 pounds at the beginning of the experiment, fed pumpkins alone at the New Hampshire Station[b] for twenty-five days, made an average daily gain of 1.12 pounds, the cost of feed per 100 pounds of gain being $2.39.

Another test at the same station[c] with a ration of cider or windfall apples and pumpkins, equal parts, cooked, showed good but expensive gains, the high cost being attributed to the apples.

ROOTS AND TUBERS.

Feeding roots to live stock is comparatively recent in the United States. Corn, with hay and ensilage, has been the principal maintenance during the winter months when pasture was not available. In hog feeding it is safe to say that, until very recent years, almost the only substitutes for pasture were pumpkins, artichokes, and clover or alfalfa hay in certain sections. In England and Canada, however, much dependence is placed on roots, and while we may never reach the point in this country generally of fattening animals almost entirely on a root diet, the peculiar advantages to be gained by them, their great palatability, and the good effect on the health and thrift of the animal commend roots to the stockman.

A number of experiments have been reported recently on feeding roots to hogs.

At the Indiana Station Plumb and Van Norman[d] conducted two experiments to compare a ration composed solely of grain with one where roots were added. In both experiments the grain ration was 1 part corn meal, 2 parts shorts, fed as slop. No drink other than water was given. In the first experiment mangels were fed; in the second the roots were sugar beets sliced and fed in the slop, and they were relished more than the mangels.

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[a] Bul. No. 47, Bureau of Animal Industry.
[b] Bul. No. 66.
[c] Bul. No. 66.
[d] Buls. Nos. 79 and 82.

At the Ontario Agricultural College Day[a] fed four lots of pigs in pens as follows:

Lots I and II were made up of 4 grade Yorkshire pigs, each from the same litter, about 7 weeks old; Lots III and IV contained 5 grade Yorkshire pigs, each from the same litter, about 9 weeks old. Lot I received barley and middlings; Lot II received barley and middlings with an equal weight of raw pulped mangels; Lot III received corn and middlings; Lot IV received corn and middlings with an equal weight of raw pulped mangels. The proportion of grain in middlings was 1:2 in all lots at the beginning of the experiment, and was gradually changed as the pigs increased in weight and age until it was 2:1 toward the close.

At the Utah Station Foster and Merrill[b] conducted two experiments to compare a ration of bran and sugar beets with rations of corn meal, ground wheat, and corn meal and peas. In the first experiment Lot I received corn meal, Lot II received ground wheat, and Lot III received sugar beets with a one-third ration of bran. In the second experiment Lot I received a mixture of equal parts of corn meal and ground peas, Lots II and III being fed as in the first test. The pigs were fed in covered pens, and were given all they would eat. There were 3 in each lot.

At the Montana Station Shaw[c] fed one lot of hogs on grain only and another on the same grain ration with sugar beets added.

The Indiana results showed larger and more rapid gains in both cases for the pigs receiving no roots, but in one test there was a saving of 72 pounds of grain for 100 pounds of gain by feeding 410 pounds of roots. The Ontario and Montana results favored root feeding in all respects. The gains were larger and more rapid, and less feed per 100 pounds of gain was required when roots were fed. The average of these experiments show that in six out of seven tests where roots were fed there was a saving of grain.

The average of feed per 100 pounds gain shows that feeding 427 pounds of roots saved 83 pounds of grain, or 19 per cent, which is a very high value for roots.

This feature of root feeding has previously been remarked upon in this bulletin. Attention is called to it in nearly every instance where experimenters have feed roots successfully. Plumb and Van Norman[d] do not regard their results as showing great value for roots, but think that they have an effect on the appetite, digestion, and general health that is beneficial, particularly in winter. In the Ontario[b] experiments the equivalent for 100 pounds of meal was 319 pounds of roots in the first and 564 pounds in the second. Day calls attention to the fact

[a] An. Rpt., 1901.
[b] Bul. No. 70.
[c] Bul. No. 27.
[d] Bul. No. 79, Indiana Expt. Sta.

that both figures are very high values for roots, and points out that, "according to analyses and digestion experiments, there is approximately about nine times as much digestible matter in a mixture of corn and middlings as there is in mangels. It is difficult to explain, therefore, how 564 pounds of mangels should prove equal to 100 pounds of meal." The pigs receiving mangels showed the effects of their feed in more growth and thrift than the others. They had less tendency to become fat, and the root ration was reduced for this reason. Day[a] explains this effect of root feeding to be due to a "beneficial effect on the digestive organs of the animals, causing them to digest their food better than did the others; for there is little doubt that hogs closely confined in pens are likely to suffer from indigestion." Shaw[b] explains the marked effect of roots in similar words, stating that the value for sugar beets for pigs is "derived not so much from the nutrients in the dry matter which they contain as from the influence they exert on digestion and assimilation."

Henry found the results at three American experiment stations to be that about 615 pounds of roots saved 100 pounds of grain. The Danish experiments give 600 to 800 pounds of mangels and from 400 to 800 pounds of fodder beets as the feeding equivalent of 100 pounds of grain.[c]

The average of the results here given indicates that about 515 pounds of roots saved 100 pounds of meal, a somewhat higher value for roots than that given in previously published work.

A more extended experiment conducted by Shaw[d] at the Montana Station showed an average daily gain for pigs of 1.58 pounds, at a cost of $4.60 per 100 pounds gain, on grain only (9.11 pounds of grain per head daily); a second lot, on grain and sugar beets (6.65 pounds grain and 4.58 pounds sugar beets per head daily), made an average daily gain of 1.64 pounds, at a cost of $3.80 per 100 pounds. There were 4 pigs in each lot, and they were fed fifty days. As a side light on the possibilities of pork production in the irrigated Northwest, it is interesting to note that Shaw found his net profit from feeding these 8 pigs to be $14.12, "or 33 per cent on the investment in fifty days."

In an experiment to compare the feeding value of forage beets, sugar beets, mangels, and turnips, at the Central Experimental Farm of Canada,[e] when pigs received a ration of mixed grain, the pigs on forage beets made the greatest average daily gains and required the least feed for 100 pounds gain, the other lots standing in the order of sugar beets, mangels, and turnips. The results are remarkably low in feed requirements, and would seem to show that roots and milk may be more advantageously combined than pasture and milk.

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[a] An. Rpt., 1901, Ontario Agricultural College.
[b] Bul. No. 27, Montana Expt. Sta.
[c] Feeds and Feeding, pp. 570, 571.
[d] Bul. No. 37.
[e] An. Rpt., 1901.

Day, at Guelph, and Shutt, at Ottawa, have found that the effect of roots on the carcass is not detrimental, but produces a firm bacon of good quality—a very essential matter to Canadian pig feeders. In this experiment neither buyers nor packers criticised adversely the pigs fed on turnips and mangels, and the carcasses of the sugar-beet pigs were all "select" (there was no packer's report on this lot); but the buyer found one carcass too fat in the lot fed on forage beets, and the packer's report was not so favorable as on the others.

An attempt at the Colorado Station [a] to maintain pigs on sugar beets alone was successful only in maintaining them without loss. The ration proved expensive, and there was difficulty at first in inducing the pigs to eat beets, but after they became accustomed to such a diet they took to it readily. At no time were they able to eat beets enough to approach the conventional feeding standard; 12.5 pounds daily was the greatest amount they would take.

An experiment at the same station, [a] when sugar beets and sugar-beet pulp were compared, showed that the whole beets had greater feeding value than the pulp, but both rations were inferior to one of a mixture of equal parts of wheat and barley, so far as amount and rate of gain and profits were concerned, although the pigs on beets or pulp received the same grain ration as the lot on grain alone. The beet and pulp rations required less grain for 100 pounds of gain than the grain ration, and the pulp ration cost 20 cents less per 100 pounds gain than the grain ration, but the profit on the latter lot was greatest. The pigs ate pulp with considerable reluctance, and did not seem to relish the beets at first.

Clinton [b] reports an unsuccessful attempt at Cornell to feed potatoes, raw and cooked. Some grain and skim milk were given in addition; but, while over 400 pounds of potatoes were eaten, the pigs made no progress and were getting out of condition when the experiment was brought to a close. The low temperature while the pigs were being fed, ranging between 29° and 30° F., is suggested as a reason for the poor results.

At the Central Experimental Farm [c] very satisfactory results were obtained from cooked potatoes, but raw potatoes produced little gain. In one experiment the pigs were given all the raw potatoes they would eat, but made no gain and the tubers were discontinued. In a second test a similar experience led to a change to cooked potatoes. The opinion of investigators at this station is that raw potatoes are of little value for feeding pigs, but when cooked they are worth about one-fourth as much as mixed grain.

The Alabama, South Carolina, Maryland, and Florida stations have experimented with sweet potatoes, with somewhat varying results.

[a] Bul. No. 74. [b] Bul. No. 199, Cornell University Expt. Sta. [c] Bul. No. 33.

At the Alabama Station, Duggar[a] fed one lot of pigs on a ration of three-fourths sweet potatoes and one-fourth ground cowpeas and another on a ration of equal parts of corn meal and cowpeas. After four weeks they were put through an intermediate period of one week and the rations were reversed, the lot that had formerly been on corn meal and cowpeas receiving the sweet-potato ration. This was continued for four weeks longer, so that in all there were eight weeks' feeding on a sweet-potato ration.

The ration of sweet potatoes and cowpeas proved very inferior to the ration of corn meal and cowpeas. The increase in live weight was nearly twice as great in the case of corn meal and cowpeas, and the dry matter per 100 pounds of gain was estimated at 600 pounds where sweet potatoes were fed to 360 pounds where corn meal was fed. Duggar refers to the difficulty of inducing the pigs to eat enough dry matter when sweet potatoes made up so much of the ration, and suggests a ration of equal parts of cowpeas and sweet potatoes as being more palatable and nutritious. He questions whether sweet potatoes can be profitably grown, stored, and fed to hogs unless the feeding value per bushel would be more than 10 or 15 cents. Where the pigs do the harvesting, especially on sandy soils, where the yield of sweet potatoes is ten or fifteen times that of corn, they may be an economical feed.

The results at the South Carolina Station were much more favorable to sweet potatoes. Newman and Pickett[b] fed a lot of 3 pigs, averaging 162 pounds in weight, on sweet potatoes only for forty-three days, beginning November 23. At the same time corn was fed to 3 pigs averaging 156 pounds in weight. Two pigs in each lot were high-grade Berkshires and the third was a grade Duroc Jersey.

The pigs on sweet potatoes ate 26.2 pounds per head daily and made an average daily gain of 0.86 pound. They ate 3,247 pounds of sweet potatoes for 100 pounds of gain.

The pigs on corn ate an average of 9.2 pounds of grain daily, and made an average daily gain of 1.39 pounds, requiring 602 pounds of corn for 100 pounds of gain.

It was estimated that, at 200 bushels per acre, sweet potatoes would produce 369.5 pounds of pork per acre, worth $18.47 when pork is worth 5 cents per pound. The gain from corn was 139.5 pounds of pork, and the corn yield was 15 bushels per acre on land similar to that on which the sweet potatoes were grown. At 5 cents per pound for pork, the money return for the corn was $6.97 per acre.

The Maryland Station[c] reports an attempt to maintain pigs exclusively on sweet potatoes. A lot of rather mature pigs was put on a ration of small sweet potatoes and "strings" that were fed raw twice a day for thirty-one days. It required over 5 tons of these potatoes

[a] Bul. No. 93. [b] Bul. No. 52. [c] Bul. No. 63.

for 100 pounds of gain, and the return from them was only about $1.60 per ton.

The value of this feed when given with grain was tested with a younger lot of pigs for thirty days. With this lot, 593 pounds of sweet potatoes, 277 pounds of milk, and about 60 pounds of grain were required for 100 pounds of gain, and the value per ton of the potatoes was estimated at $2.40, showing sweet potatoes to be more valuable when fed with grain and milk.

The Florida Station[a] fed a lot of 4 native hogs on a ration of equal parts, by weight, of sweet potatoes and wheat middlings, the ration being 3.5 pounds of each per 100 pounds live weight of hog. They were confined in an open pen and fed twice daily. The hogs averaged 101.5 pounds at the beginning of the test and increased in weight 31.16 per cent, or 126.5 pounds, at a cost of 5.6 cents per pound of gain for feed eaten.

At the Alabama Station, Duggar[b] penned 2 shoats, averaging 116 pounds, on sweet potatoes for thirty-five days. They were given, in addition, 2 pounds of ground corn and 1 pound of ground cowpeas per head daily. In the time specified they gained 67 pounds, an average daily gain of 0.93 pound, thus requiring 313 pounds of grain in addition to the sweet potatoes for each 100 pounds gain. Duggar states that the sweet potatoes were not relished greatly and that there was much waste of them, due probably to the relatively large amount of grain fed.

At the Oregon Station[c] French took 6 Berkshire pigs from wheat stubble on October 22 and placed them on a field of artichokes that had been planted in April on deep-plowed ground, prepared, as for potatoes, in rows 3 feet apart, with the seed 18 inches apart in the row. The growth was vigorous and the yield abundant, the tops growing to a height of 7 feet during the season, and a trial plot showing a yield of 740 bushels per acre. The pigs had free access to the field and did all the harvesting. An attempt to sustain them entirely on the tubers failing, some shorts were fed in addition.

At Ottawa, Grisdale[d] sowed a plot of one-sixteenth acre with about 70 pounds of tubers on May 19, planting in rows 24 inches apart, 4 inches deep, and 20 inches apart in the rows. Six pigs were turned in October 3. Although the tubers were immature at that time, the tops were from 10 to 13 feet high. The pigs were allowed a daily grain ration of 1.5 pounds of a mixture composed of one-half corn meal and one-half of a mixture of equal parts of ground oats, pease, and barley.

In the Oregon experiment, the pigs made an average daily gain of 0.81 pound for fifty days, eating 309 pounds of grain per 100 pounds

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[a] Bul. No. 55.
[b] Bul. No. 122.
[c] Bul. No. 54.
[d] An. Rpt. 1900, Central Experimental Farm.

of gain, at a cost of $1.85; in the Canadian test, the pigs made an average daily gain of 1.57 pounds for twenty-one days, eating 96 pounds of grain per 100 pounds of gain, which cost $1.80.

The cost of the meal in the Oregon experiment was estimated at $12 per ton; that in the Canadian one at $18 per ton. Valuing the meat made at $6.25 per 100 pounds, Grisdale estimates that, after deducting the cost of the meal fed, a balance of $10.61 is left for the artichokes fed, and deducting from this the cost of seed, planting, rent of land, etc., the one-sixteenth acre used gave a net return of pork worth $8.76.

ROUGHAGE.

Hogs are generally regarded as animals whose particular function is the conversion of concentrated feed into meat. Although the capacity for bulky feed that we find in the stomachs of cattle and sheep is lacking in hogs, a reasonable amount of bulk in the form of roots or hay is palatable and profitable. In many parts of the country, where concentrates are costly feeds, stockmen are forced to use substitutes for at least a part of the grain ration, both for fattening and maintenance, and over the entire country the winter ration is a problem. To solve these problems many western farmers have resorted to the use of alfalfa hay, and outside alfalfa districts clover hay is used. Considerable study has been devoted to this subject by the experiment stations.

The Kansas Experiment Station[a] has reported a series of experiments with drouth-resistant crops. Three of these experiments had to do with alfalfa hay. In the first, the hogs used were of mixed breeding—Berkshire and Poland China—representing about the average of Kansas farm hogs. The alfalfa was of good quality.

Two lots were fed—one receiving the hay whole in greater quantity than it would consume, the other having ground hay. In the second test the meal-fed lot received some cotton-seed meal—0.16 pound to each pound of Kafir corn, which did not affect the hogs seriously. This test was conducted during the most severe weather of the winter, the thermometer registering 32° F. below zero February 12, ten days after the experiment began.

In the third test the grain was wet with water at the time of feeding. The alfalfa hay had been cut late and was rather woody.

The Utah Station[b] fed one lot of hogs on a mixture of equal parts by weight of chopped wheat and bran, wet. Another lot had the same grain ration with chopped alfalfa hay added. "The alfalfa used was well cured and was prepared by running through an ensilage cutter, the blades of which are arranged for cutting into half-inch lengths." The pigs were thrifty grade Berkshires.

[a] Bul. No. 95. [b] Bul. No. 70.

The Montana Station[a] fed three lots of hogs to compare the feeding values of a grain ration with sugar beets and alfalfa hay as roughage with a ration of grain only. The lot on grain alone received a ration consisting, during the early part of the experiment, of 2 parts of damaged wheat and 1 part oats, barley taking the place of the wheat during the latter part of the experiment. The hay-fed lot had the same ration with alfalfa hay added. The alfalfa hay was run through a cutting box, moistened, and mixed with meal. The hogs were by a Berkshire boar out of high-grade Poland China sows. They had previously had the run of a stubble field, with some clover pasture.

The average of these experiments[b] shows that 593 pounds of grain were required for 100 pounds of gain when no hay was fed, and 505 pounds of grain and 89 pounds of alfalfa hay when hay was fed, a saving of 88 pounds of grain to be credited to the hay fed.

In all but two instances a considerable saving of feed was found to be effected by its use, but the statement that its feeding value is almost equal to that of corn is true only within certain limits. Where hogs are confined to an exclusive grain ration, and especially where this is made up of a single grain, the addition of a moderate amount of hay to the ration will be relished and less grain will be required. At the same time, better and cheaper gains are usually made by hogs so fed than by those on grain alone, but the value of the grain saved is out of all proportion to the value of the hay fed, and the hay in the ration can not be used economically in more than very moderate amounts. This is a similar fact to that which has been found by many investigators with such bulky feeds as green clover, rape, roots, and skim milk. That it is bad economy to attempt the maintenance of hogs on alfalfa hay alone is shown by an experiment by McDowell[c] in Nevada.

In this experiment, two lots of 2 pigs each were fed on a ration of alfalfa hay. The two lots ate in twenty-one days 99.12 pounds and 99.14 pounds, respectively, and lost in weight 33.25 pounds and 51 pounds, respectively, an average daily loss of 0.79 pound and 1.21 pounds, respectively. "While feeding hay alone the pigs spent much time curled up in the bedding, but when about the stalls were restless, and even in eating it was done in a ravenous way, unlike that of a hearty, well-fed pig." After the hay-feeding period both lots were given grain and roots and made satisfactory gains.

A consideration of the approximate proportions of hay to grain fed in these experiments is of interest. The greatest proportion of hay to grain was fed at the Kansas Station and the ratio was 1:2.5. With this ratio the least daily gain was made. The gains were the most expensive of any of the lots, and no advantage accrued from the use

[a] Bul. No. 27.

[b] See Bul. No. 47, p. 174, Bureau of Animal Industry.

[c] Bul. No. 40, Nevada Expt. Sta.

of hay. The least proportion of hay (1:11) was fed at Utah and gave the most economical gains. The greatest daily gain and the greatest amount of grain saved was in a Kansas lot fed whole alfalfa hay and dry Kafir corn meal in the proportion of 1:7. The following table shows the effect of these rations in greater detail. The best results seem to come from the use of hay in the proportion of from one-seventh to one-fourth of the ration when hay makes up all the roughage.

Ratio of hay to grain in feeding hogs.

Ratio of hay to grain.	Average daily gain.	Feed per 100 pounds gain.		Grain saved.
		Grain.	Hay.	
Kansas:	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*
1:2.5	0.88	538	214	1.8
1:4	1.37	501	131	139
1:4	1.37	516	123	137
1:7	1.44	515	72.4	234
1:7	1.32	538	78.7	211
Montana:				
1:7	1.19	486	67	46
Utah:				
1:11	1.19	455	41.7	9

The average[a] of experiments at the Utah and Montana stations show sugar beets to be more valuable as roughage than alfalfa hay. Pigs on hay and grain required 423 pounds of grain and 123 pounds of hay for 100 pounds of gain; those on beets required 358 pounds of grain and 617 pounds of beets for 100 pounds of gain—a difference of 65 pounds of grain, or 15 per cent, in favor of the sugar-beet rations.

Recent results at the Colorado Station[b] have been unfavorable either to hay or sugar-beet feeding for pigs. Nine Berkshire pigs, averaging about 150 pounds, were fed. Lot I received a mixture of approximately 2 parts barley and 1 part corn, and about one-half pound alfalfa hay daily; Lot II had the grain ration only; Lot III had the grain ration and about 1 pound of sugar beets daily. There was some difficulty at first to get the pigs in Lot I to eat alfalfa, but when it was cut fine and mixed with barley slop they would take it.

The pigs on grain only made the largest and most rapid gains, and required the least grain for 100 pounds of gain. These pigs also made the cheapest gains and the largest profit. The hay-fed pigs gave nearly as good gains as those fed grain only, but they required more feed, and the profits were 21 cents less per head for the ninety-seven days' feeding. The grain and sugar-beet ration was least effective and least economical. The proportion of hay to grain fed was approximately 1:11; that of beets to grain was a little more than 1:5.

[a] Bul. No. 47, pp. 175–177, Bureau of Animal Industry. [b] Bul. No. 74.

The Maryland Station[a] has conducted a number of experiments with ground corn fodder, or "new corn product," as it is otherwise called. This product is the ground residue of cornstalks from which the pith has been removed. It was fed to pigs varying in age at the beginning from eight to twelve weeks. All rations contained milk, and the fodder was fed in different proportions to note any possibly advantageous results from such a practice. No special advantages could be observed from feeding the corn fodder, either in lessening the amount of grain required for 100 pounds of gain or in lowering the cost, except after the pigs were 6 months old. For fairly mature pigs the "new corn product" probably would have an effect in a ration somewhat similar to that of alfalfa hay.

BREED TESTS.

In the foregoing pages attention has been called to the fact that there is very little difference in the standards of excellence for the various breeds of what has come to be designated the "lard," "fat," "block," or "corn-belt" hog. Tests of the different breeds made in different parts of the country show that there is very little difference in the cost of pork production by the best representatives of any of the established breeds.

One of the most striking facts to be observed in the study of breed tests by the experiment stations is the apparent contradiction of the evidence of different experiments. For example, Curtiss and Craig[b] quote Hayward, of the Pennsylvania Station, to the effect that the results obtained in Maine, Massachusetts, and Ontario show the feed eaten per 100 pounds gain by various breeds to be as follows: Poland China, 407 pounds; Berkshire, 419 pounds; Tamworth, 420 pounds; Chester White, 500 pounds; Duroc Jersey, 522 pounds.

To ascertain what results might disclose if a broader average were taken, the writer[c] averaged the feed per 100 pounds of gain found at eight experiment stations. Only those experiments were used where there was a sufficiently exhaustive test and a large enough number of pigs to make the results fairly representative. It was found that the least amount of feed for 100 pounds of gain was shown by the Tamworths, 344 pounds, and the greatest by the Duroc Jerseys, 418 pounds, the other of the six leading breeds standing in this order: Chester White, Poland China, Berkshire, Large Yorkshire. Similarly contradictory results may be found in almost every breed experiment conducted. In the Iowa tests, which covered three years, the Yorkshires averaged highest in average daily gains, with 1.04 pounds; the Berkshires and Duroc Jerseys being tied for second, with 0.98

[a] Bul. No. 63.
[b] Bul. No. 48, p. 444, Iowa Expt. Sta.
[c] Bul. No. 47, p. 178, Bureau of Animal Industry.

pound, and the others following in this order: Tamworth, Poland China, Chester White, the lowest being 0.89 pound. In feed requirement (estimated digestible dry matter for 100 pounds gain) the Duroc Jerseys were first in least requirement, with 410 pounds, the other breeds standing thus: Poland China, Yorkshire, Chester White, Tamworth, the last being 456 pounds. In cost of 100 pounds of gain the Yorkshires were lowest, with $2.14, the other breeds taking this order: Poland China, Duroc Jersey, Tamworth, Chester White, the highest being $2.46. In the work at the Ontario Agricultural College[a] the results of four tests with the same breeds show that the Duroc Jersey averaged first in average daily gains, with 1.01 pounds, the other breeds following in this order: Yorkshire, Berkshire, Tamworth, Poland China, and Chester White. There was, however, very little difference between the Duroc Jersey, Yorkshire, and Berkshire in respect of average daily gains, and the Tamworth, Poland China, and Chester White formed a second group, with average daily gains of slightly more than 0.90 pound. In the economy of gain the Berkshire stood first, with 379 pounds as the amount of meal required for 100 pounds of gain, the other breeds following in this order: Tamworth, Yorkshire, Duroc Jersey, Chester White, and Poland China. In this respect the Berkshire was quite a little in the lead. The Yorkshire and Duroc Jersey formed a group around 395 pounds and the Chester White and Poland China another group at 400 pounds. The Tamworth required 390 pounds of meal for 100 pounds gain—somewhat less than the Yorkshire and Duroc Jersey. The lowest average daily gain was 0.90 pound, and the highest amount of feed required for 100 pounds of gain 402 pounds. In the Minnesota tests,[b] on the other hand, the Tamworth and Yorkshire showed more favorable results than the Poland China.

These results undoubtedly show the truth of the rather hackneyed phrase, "There is no best breed." Given the improved breeds and there seems to be practically no difference in the feeding powers between representative animals of any of them. One breed may contain more good feeders than another, but the good judge can find among them all animals which will feed rapidly and economically. Not only is this true of the hogs of the "lard" type, but the bacon breeds must be included in the category if we accept the figures of the stations as correct. The fact that a pig is a Yorkshire or a Tamworth can not be taken as prima facie evidence that it will make slow or expensive gains.

Breed influence, however, may be noticed on the carcass. It is notorious that the low prices which are paid for American bacon on the English market are caused by the fact that the type bred in the United

[a] An. Rpts., 1896–1900. [b] Bul. No. 73.

States does not suit the English taste and that the feed given is not always that which will produce a first-class carcass. The results of experimental shipments of pork to this market are therefore particularly interesting to pig feeders. After each slaughtering of the Iowa pigs some of the pork was shipped to Liverpool for sale on the English market. Very complete reports were received regarding the suitability of these cuts abroad.

In 1897 the opinion of the packers, before the shipment was made, was that the Berkshire and Tamworth pigs were "the most suitable for the making of English meats."[a] The lots of pork that were unsuitable on account of feeding were one of long-cut hams from Poland China pigs and one of long-cut hams from Chester White pigs, which were "too fat and short." One lot of American-cut hams from the Berkshires was rendered unsuitable for the English market by cutting. Some of the cuts were criticised as soft and spongy, others as somewhat fat, but they were not necessarily condemned on account of fat. A tendency in the Yorkshire long-cut hams to be "rather stout" was remarked upon.

In 1898 a still more complete report was received concerning the cuts that were shipped to England. The cuts from the Tamworths were all reported suitable for the English trade, although some were criticised as being somewhat too fat. The Berkshire cuts were given second place, only two being condemned as being too fat for the British market. The showing of the Yorkshire cuts in this shipment was surprising. Out of eight Cumberlands cut from Yorkshire pigs only one was suitable for export, the others being "much too fat." Out of eight Yorkshire short-cut hams four were condemned on account of fat. The Yorkshire cuts were the least suitable of the shipment.

This characteristic of the Yorkshires in this experiment brings up the very important question regarding the influence of feed on the carcass. It also shows how individual and family characteristics are strong factors in experimental work. In justice to the breed it should be said that it is highly valued for its high-class pork products and is employed in every country where the production of prime bacon is a feature of pig feeding. The breed is more extensively used than any other in Denmark, where the finest bacon of international trade is produced. Yet in the Iowa tests it was said that the Yorkshires were deficient, "as the thickness of fat on the back was much greater than the trade desired."[b] The suitability of the Yorkshires for the export bacon trade is shown in the résumé on the Ontario Agricultural College work in the following paragraph:

Summarizing the results of five years of work with six breeds at

[a] Bul. No. 48, p. 391, Iowa Expt. Sta.
[b] Bul. No. 48, p. 429, Iowa Expt. Sta.

Guelph, Day would rank the Yorkshire first in suitability for the export trade, placing the Tamworth second and the Berkshire third. The showing of the other breeds that were fed (Chester White, Duroc Jersey, and Poland China) was so unsatisfactory in the production of export bacon that they could not be graded.[a] In a breed test inaugurated in collaboration with the Dominion department of agriculture the Yorkshires and Berkshires were the only breeds that made a satisfactory showing. "There were practically no culls among these breeds."[b]

FEEDING FOR PRIME BACON.

The criticism to which our bacon is open when it comes into contact with the products of other countries in the world's markets would seem to call for more attention by American feeders than has been given in the past to the production of prime bacon for the foreign trade, especially that consumed by England, which country is our best customer. The bacon from the United States forms the greater part of all this product imported by that country, but it has never equaled the Danish bacon in price, and in this respect it has generally been behind that imported from Canada also. While American bacon is said to have a better standing on this market at present than in former years, we can hardly yet claim superiority for it; and whatever advance in quality has been made must be attributed rather to the enterprise of the packers than to increased skill on the part of the breeder or the feeder.

Canadian farmers depend upon their exports of bacon to a very great extent, and its maintenance is a source of solicitude. Day, at the Ontario Agricultural College, and Grisdale and Shutt, at the Central Experimental Farm, have studied the production of export bacon during the past eight years to ascertain the best methods of feeding and breeding, and also the prevention of deleterious properties in its production.

Lack of space prevents more than a brief notice here of the studies conducted in Canada to raise the standard of the bacon from that country.[c] In meeting the problem, the most conspicuous fault found with the usual Canadian product was a tendency to softness. This was a different condition from the softness which troubles pork curers in the Southern States. It was the development of a flabby condition of the sides while they were in the salt and did not seem to depend, necessarily, on the season of the year when the pigs were slaughtered, although soft bacon appeared to be more prevalent in May, June, and July. Soft sides were more common from hogs fed in lower Ontario (Essex and Kent counties), where large quantities of corn are fed.

[a] An. Rpt., 1900, p. 48, Ontario Agricultural College.

[b] An. Rpt., 1901, p. 62, Ontario Agricultural College.

[c] The subject is reviewed at greater length in Bulletin No. 47 of the Bureau of Animal Industry.

Investigation showed that those sides were soft which contained relatively large amounts of fluid fats, principally olein, and that when the proportion of palmitin and stearin in the fat was relatively large the sides were firm. The soft tendency was also found to be more marked when immature and unfinished pigs were slaughtered than when pigs were matured and fed to a finish. The principal trouble, however, was soon traced to the large amounts of corn, and rations were devised to counteract the manifestly injurious effects of this feed. After considerable experimenting, the grain which was found to be a bacon-producing feed par excellence was barley. Not only did it produce the highest quality of bacon, but when fed in combination with corn in various ways the softening effect of the corn was prevented to a great extent. In the first series of experiments at Ottawa the bacon which showed the lowest precentage of olein was fed on rations of equal parts of oats, pease, and barley. Bacon fed on a ration of one-half corn meal and one-half of a mixture of equal parts of oats, pease, and barley compared very favorably with it. The rations which produced bacon with the highest olein content and the lowest melting point were those made up largely of beans or consisting entirely of corn meal.

In the second series of experiments the best results came from a grain ration half of which was corn meal, the other half being a mixture of equal parts of oats, pease, and barley, with skim milk and sugar beets in addition. A ration of pease alone gave nearly as good results. The poorest results came from corn meal alone and beans alone.

In this series of experiments and in the work of Day at Guelph the effect of skim milk was strikingly shown. One of the best lots of bacon in the second series at Ottawa was fed on a ration of corn meal and skim milk. This shows that the American farmer has it in his power to produce a grade of bacon which will be unsurpassed. In those sections of the country where corn can not be produced, but where barley is an abundant crop, he has the best bacon-producing grain known. In the corn belt, where the most abundant crops of corn are at his command, he can neutralize the injurious effects of this grain on the carcass by the use of skim milk.

It is not idle fancy to urge American farmers to consider the tastes which the Englishman wishes to gratify in regard to the bacon he buys. The American bacon commands the English market by reason of its overwhelming quantity, not by its quality. It is entirely outclassed by the Danish bacon and sells below the Canadian product.

During the fifteen years for which we have figures regarding Danish bacon the valuation per 100 pounds has been less than $11 in three years only (1895, 1896, and 1899), and in one year only (1896) has it fallen below $10, when a valuation of $9.93 was reached. In the years

1893 and 1901 it was more than $13. On the other hand, in the years 1893, 1901, and 1902 only has bacon from the United States had a valuation of more than $9 per 100 pounds, and in the years 1893 and 1902 only, when extremely high prices were recorded in this country for live hogs, has the valuation been in the neighborhood of $11 per 100 pounds, being $11.02 and $10.90, respectively, in these years. In no year has it sold up to the average valuation per 100 pounds of the total imports of bacon into the United Kingdom. In three years—1888, 1893, and 1902, all years of high prices in this country—the difference in value per 100 pounds between Danish and United States bacon has been less than $2.50, as follows: 1888, $2.48; 1893, $2.09; 1902, $2.07. In 1895 the difference was less than $3.50, but in all other years it was more than $3.50, a difference of more than $4 being noticed in the years 1889, 1890, 1891, 1892, 1897, and 1898, and a difference of over $5 in the years 1890 and 1897. The greatest difference was in 1890, when the Danish bacon averaged $5.20 per 100 pounds more than that from this country. The average valuation per 100 pounds of all bacon imported into the United Kingdom for the entire period from 1888 to 1902 was $8.94; that of the United States bacon was $8.07, and that of the Danish bacon $11.83, a difference of $3.76 in favor of the Danish bacon.

Further evidence of the fact that Danish bacon stands higher in the esteem of the English people than that produced in the United States is that there is less fluctuation in its value on that market in periods of greatest supply. In other words, when a shortage in the American supply sends prices up and diminishes exports from this country, the price of the Danish bacon, while rising somewhat, does not increase in so great a proportion as that from the United States. On the other hand, when supplies increase in this country, causing prices to fall and exports to increase, the American product decreases in price on the English market to a greater extent than the Danish. The Danish bacon therefore seems to supply a trade that buys it more steadily, and, to a certain extent, regardless of price, whereas the American product goes to the trade which buys it in largest amount when the price is low and curtails purchases when the price rises.

THE EFFECT OF HOG RAISING ON THE FERTILITY OF THE LAND.

The Arkansas Station[a] noted the effect which the grazing of pigs and the growth of leguminous crops had on the soil and the cotton yield per acre. Cotton was grown on plats where pigs had grazed peanuts, chufas, or soy beans, and a fourth plat, which had been in corn which had been cut and the stover removed therefrom, was used

[a] Bul. No. 68.

as a check. The yields of seed cotton per acre were as follows: On the peanut-grazed plat, 1,771 pounds; on the chufa-grazed plat, 1,200 pounds; on the soy bean-grazed plat, 1,588 pounds; on the corn plat, 1,005 pounds. During the succeeding year the cotton yield was noted on the same plats, no fertilizers having been applied. Some decrease of yield was caused by unfavorable climatic conditions. The yields were: On the peanut-grazed plat, 1,134 pounds; on the chufa-grazed plat, 981 pounds; on the soy bean-grazed plat, 1,020 pounds; on the corn plat, 798 pounds.

These figures show that during the first year after grazing on peanuts, soy beans, and chufas the manure left by the pigs, supplemented by the fertilizing properties of the plants themselves, increased the yield of seed cotton from nearly 20 to more than 76 per cent per acre over the yield from a plat where corn had been grown; and that during the second year the yield in favor of the grazed plats was still apparent, ranging from over 22 per cent to over 42 per cent more on the grazed than on the ungrazed plats. Naturally some of the increased yield must be attributed to the fertilizing value of the peanuts and soy beans, but as chufas are not leguminous plants, and therefore are not equipped with nitrogen-gathering bacteria, the figures, where they were used, show quite accurately the manurial effect of the grazing. The increased yield on the chufa-grazed plats was nearly 20 per cent the first year after grazing and over 22 per cent the second year after.

The Tennessee Station[a] calculated the value of the manure made by pigs in experiments at Knoxville. In the experiments of 1902–03 the available manure was estimated at 75 per cent of the excrement voided by the animals, and its value was calculated by estimating nitrogen at 15 cents per pound, potash at 5 cents, and phosphoric acid at 5 cents.

The following table shows the estimated value of the manure made. There were 3 pigs in each lot in the tests of 1902 and 4 in each lot in 1903. They were fed sixty days in 1902 and seventy-seven days in 1903.

Value of manure in pig feeding.

Ration.	Value of manure.
Wheat meal, corn meal, and skim milk	$3.43
Wheat meal, corn meal, and skim milk	4.34
Wheat meal, corn meal, and skim milk	5.00
Wheat meal, corn meal, and skim milk	5.23
Wheat meal, corn meal, and skim milk	4.18
Soy-bean meal, corn meal, and skim milk	4.91
Corn meal and skim milk	4.04
Corn meal	1.20

[a] Vol. XVI, Bul. No. 3.

The high fertilizing value of rations composed to a considerable extent of nitrogenous feeds, such as the skim-milk rations and the soy-bean-meal ration, is apparent.

The value of manure as a by-product of animal husbandry can not be too strongly emphasized, especially in those sections of the country, like the South, where the fertility of the land has, to a certain extent, been lost. The South supports the greater part of the business of the country in commercial fertilizers, and, while paying enormous sums annually in this manner, can not look forward to anything but greater impoverishment of the soil unless the production of live stock is increased and the manure carefully utilized.